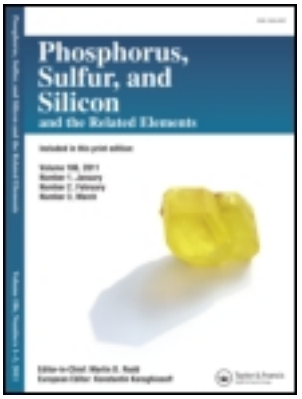

Phosphorus, Sulfur, and Silicon and the Related Elements

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Synthesis of Some Novel S- and N,S-Substituted Chlorobutadienes

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SYNTHESIS OF SOME NOVEL *S*- AND *N,S*-SUBSTITUTED CHLOROBUTADIENES

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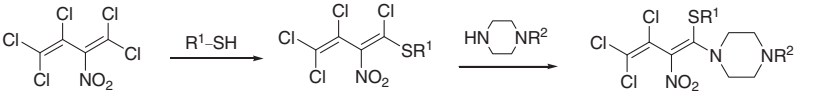
Division of Organic Chemistry, Department of Chemistry, Faculty of Engineering, Istanbul University, Istanbul, Turkey

GRAPHICAL ABSTRACT



Abstract *Mono(thio)substituted nitrodienes were synthesized by reactions of 2-nitropentachloro-1,3-butadiene with some thiols [(tert-butylbenzyl)thio- and 2,3,5,6-tetrafluorophenylthio-] either directly or in ethanol in the presence of sodium hydroxide.* N,S-*Substituted 1,3-butadienes were obtained from the reaction of the mono(thio)substituted nitrodienes with morpholine and some piperazine derivatives in dichloromethane. Also mono- and di(thio)substituted perchlorobutadienes were synthesized from the reactions of hexachloro-1,3-butadiene with o-aminothiophenol in ethanol in the presence of sodium hydroxide. The structures of the new compounds were characterized by microanalysis and spectroscopic data.*

Keywords Morpholine; *N,S*-substituted nitrodiene; piperazine derivatives; polychloro-1,3-butadiene; thioether

INTRODUCTION

It has been reported previously that some mono-, bis-, tris-, tetrakis, and pentakis(thio)substituted diene compounds can be prepared from hexachloro-1,3-butadiene.[1–8] We have obtained the novel *N*,*S*-substituted nitrobutadienes by reaction of some mono(thio)substituted nitrobutadienes with morpholine and piperazine derivatives.[9–16] Substituted piperazine compounds are important for clinical chemistry[17] and also have been subjected to medicinal applications and gene transfer studies due to their interesting biological activity and chemical effects.[18] Substituted morpholines enhanced the activity against Gram-positive bacteria.[19]

Nitro-1,3-butadienes, especially their halogen derivatives have proved to be useful precursors for synthesizing new complex polyfunctional derivatives of different compound classes and various functional heterocyclic compounds showing antibacterial, antiviral, antihelmintic activity as well as antiarrhytmic, antihypoxic, and antitumor activity.[20]

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The aim of this work was to synthesize novel *S*-, *S*,S-, *S*,*S*,*S*-, *N*,*S*-substituted chlorobutadienes by carrying out reactions of hexachlorobutadiene and 2-nitro-pentachloro-1,3-butadiene with some thiols and *N*-nucleophiles and to characterize the structure of these novel compounds.

RESULT AND DISCUSSION

The mono(thio)substituted compounds **3a** and **3b** were obtained from the reactions of **1** with **2a** and **2b**. The tris(thio)substituted compound **4a** was prepared by the reaction between **1** and **2a** in the presence of NaOH in EtOH. The mono(thio)substituted compounds **3a** and **3b** were treated with some piperazine derivatives and morpholine in dichloromethane. The *N,S*-substituted nitrodiene compounds **6a**, **8a–c**, **10a**, and **12a** were achieved from the reactions of **3a** with **5**, **7a**, **7b**, **7c**, **9**, and **11**, respectively. In the same way, **6b** and **8d–f** were synthesized from the reactions of **3b** with **5**, **7a**, **7b**, and **7c**, respectively. The new *N,S*-substituted nitrodienes were obtained in good yields and are stable yellow solids. These substitution reactions proceed via an addition-elimination reaction mechanism.[9] The new compounds were purified by column chromatography.

The mono- and bis(thio)substituted butadiene compounds **14** and **15** were prepared by the reaction of hexachloro-1,3-butadiene **13** with *o*-aminothiophenol in the presence of NaOH in EtOH (Scheme 1).

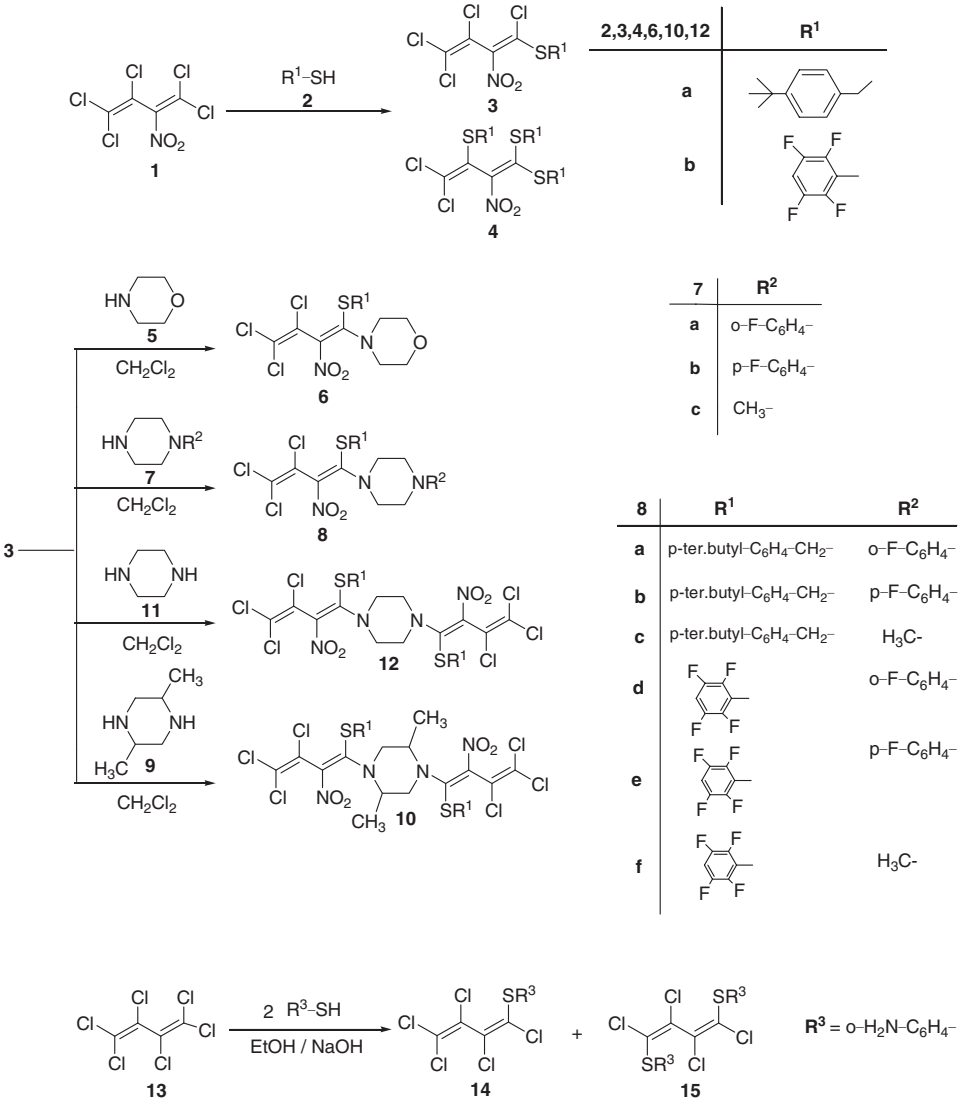
The structures of all products were determined by microanalysis and spectroscopic data such as IR, ^{1}H NMR, ^{13}C NMR, and MS. The spectroscopic characterization of all compounds is reported in the experimental section. All these new compounds gave spectroscopic data in accordance with the proposed structures.

The mono(thio)substituted nitrobutadiene compound **3a** gave ^{1}H NMR methyl signals at $\delta = 1.24$ ppm and methyl ^{13}C NMR signals at $\delta = 30.23$ ppm. The mass spectrum of the tris(thio)substituted nitrobutadiene **4a** in the positive ion mode for ESI confirmed the proposed structure; the molecular peak was identified at *m/z*: 701.78 $[M]^{+}$. The molecular peak of **4a** was given in Figure 1.

The ^{1}H NMR spectrum of **3b** exhibits aromatic proton multiplets at $\delta = 7.23$–7.33 ppm. In the ^{13}C NMR spectra of compounds **6a**, **8a**, **8b,** and **8c**, which contain the morpholine and piperazine ring, the morpholine carbons were observed at $\delta = 52.55$, 65.35 for **6a**, the piperazine carbons were observed at $\delta = 49.35$, 52.32, $\delta = 49.45$, 52.04, $\delta = 48.22$, 49.70 ppm for **8a**, **8b**, and **8c,** respectively.

In the IR spectra of **10a** and **12a,** no lines in the region 3200–3450 cm^{-1}, region attributable to the streching vibration of the bonded N-H group, were observed. So it was obvious that the butadienyl groups were connected from both sides to piperazine ring to form disubstituted butadienyl piperazine compounds. In the ^{1}H NMR spectra of compounds **6b**, **8d**, **8e**, and **8f**, which contain the morpholine and piperazine ring, the morpholine protons were observed as three broad singlet at $\delta = 3.85$–3.28 ppm for **6a**, the piperazine protons were observed as three broad singlet at $\delta = 2.80$–4.14, $\delta = 2.88$–4.11, $\delta = 2.05$–3.95 ppm for **8d**, **8e**, and **8f**, respectively. The IR specta of **14** and **15** showed a characteristic N-H streching band for the NH_2 group at $\nu = 3382$, 3478 cm^{-1}, and $\nu = 3379$, 3475 cm^{-1}, respectively.

The title compounds, $C_{15}H_{15}Cl_4NO_2S$ and $C_{20}H_{13}Cl_3F_5N_3O_2S$, contain the expected *N*,*S*-substituted butadienyl skeleton, phenly rings, and a piperazine ring for **8d**. The butadiene unit was not completely planar as one would expect if the double bonds were fully conjugated. The C—C bond lengths of the butadiene chain are 1.311(2)Å, 1.475(3)Å,



Scheme 1 Reaction of chlorobutadienes **1** and **13** with thiols and monothiosubstituted nitrodienes with derivatives of amines.

1.357(2) Å for compound **3a** and 1.287(5) Å, 1.471(4) Å, 1.390(4) Å, respectively, for C_1-C_2, C_2-C_3 and C_3-C_4 .The observed values in **3a** and **8d** are consistent with the corresponding values in similar compounds.[21] The phenyl ring is planar with a maximum deviations of 0.0075 Å (plane 1: C6-C7-C8-C9-C10-C11) in compound **3a**. In the compound **8d**, the piperazine ring adopts a chair conformation and planar with a maximum deviation of 0.0174(1) Å. The distances of two chair atoms in the *para* positions (N2 and N3) from the plane of the other four atoms of the six-membered piperazine ring are 0.631 (1) Å and −0.672(1) Å, respectively. The two phenyl rings of compound **8d** are planar with maximum deviations of 0.0043 Å (plane 1: C5-C6-C7-C8-C9-C10) and 0.0028 Å (plane

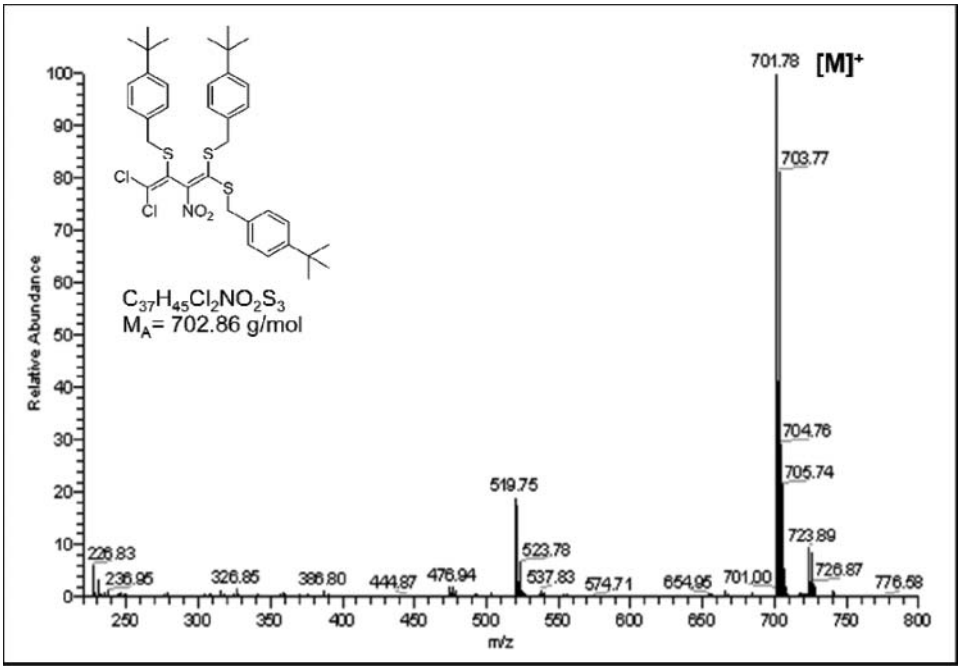


Figure 1 Full-MS spectrum of compound **4a** in the positive mode of ESI.

2: C15-C16-C17-C18-C19-C20). The dihedral angles are 19.0(1)°, 37.7(1)° between the planes of the phenyl rings (plane 1 and plane 2) and piperazine ring, respectively. Yellow single crystals of **3a** and orange single crystals of **8d** crystallized from ethanol and were unambiguously characterized by means of X-ray experiments (see Figures 2. and 3 and Supplemental Materials; Tables 1 and 2).

EXPERIMENTAL

Melting points were measured on a Büchi B-540 capillary apparatus and were uncorrected. IR spectra (ν/cm^{-1}) were recorded on an FTIR spectrometer Shimadzu IR Prestige

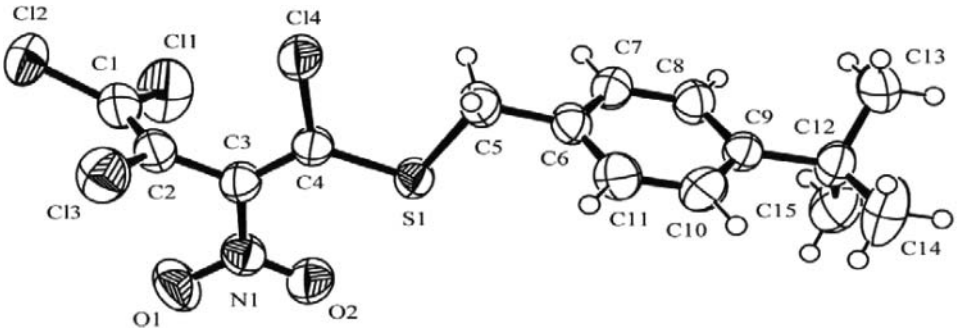


Figure 2 The molecular structure of the **3a** compound. Displacement ellipsoids are drawn at the 50% probability level.

Table 1 Crystal data and refinement parameters

	Compound **3a**	Compound **8d**
CCDC number	CCDC 852475	CCDC 851960
Empirical formula	$C_{15}H_{15}Cl_4NO_2S$	$C_{20}H_{13}Cl_3F_5N_3O_2S$
Crystal color, habit	Yellow, block	Orange, block
Formula weight	415.16	560.75
Temperature	293.1 K	293.1 K
Wavelength	0.71070 Å	0.71070 Å
Crystal system	Monoclinic	Monoclinic
Space group	$P2_1/n$	$P2_1/n$
Cell dimensions	a = 9.5473(3) Å	a = 7.3342(2) Å
	b = 16.5512(5)Å	b = 20.3489(6)Å
	c = 12.3094(4) Å	c = 15.0409(5) Å
	β = 106.700(2) Å	β = 91.438(2) Å
Volume	1863.09(10) $Å^3$	2244.04(12) $Å^3$
Z	4	4
Density (calculated)	1.480 g/cm^3	1.660 g/cm^3
F_{000}	848.00	1128.00
Crystal size	0.7 × 0.6 × 0.4 mm	0.5 × 0.4 × 0.2 mm
Index ranges	$-13 \le h \le 13$	$-8 \le h \le 8$
	$-23 \le k \le 23$	$-24 \le k \le 24$
	$-17 \le l \le 17$	$-17 \le l \le 17$
Reflections collected	110734	84162
Independent reflections	5653[R_{int} = 0.025]	4128 [R_{int} = 0.101]
Goodness of fit indicator	1.231	1.184
Final R indices [$I>3\sigma(I)$]	R_1 = 0.073, wR_2 = 0.033	R_1 = 0.043, wR_2 = 0.042
Largest diff. peak and hole	0.61 and −0.47 $eÅ^{-3}$	0.24 and −0.28 $eÅ^{-3}$

21 model Diamond, ATR method. ^1H and ^{13}C NMR spectra were recorded on a Varian Unity Inova spectrometer at 499.83 MHz for ^1H and 125.48 MHz for ^{13}C by using $CDCl_3$ as solvent and TMS as internal standard. Mass spectra were obtained on a hybrid triple quadrupole linear ion trap mass spectrometer (4000 QTRAP, ABSciex). The 4000

Table 2 Selected geometric parameters of **3a** and **8d** compounds (Å,°). H atoms were treated as riding, with C—H = 0.95 (6) Å and $U_{iso}(H) = 1.2Ueq(C)$.

Compounds	**3a**	**8d**
Bond lengths (Å)		
S1—C5	1.824 (2)	1.775(3)
C3—C4	1.357 (2)	1.390(4)
C3—C2	1.475 (3)	1.471(4)
C1—C2	1.311 (2)	1.287(5)
Bond angles(°)		
C4—C3—C2	123.6 (2)	122.9 (3)
C3—C2—C1	121.7 (2)	124.0 (3)
Torsion angels(°)		
C4—S1—C5—C6	−177.7(9)	−53.6(3)
N1—C3—C2—Cl3	87.6(2)	−81.1 (3)
C4—C3—C2—C1	88.0 (2)	−92.4(4)
N3—C12—C11—N2	—	−59.5 (4)
N3—C13—C14—N2	—	54.3 (4)

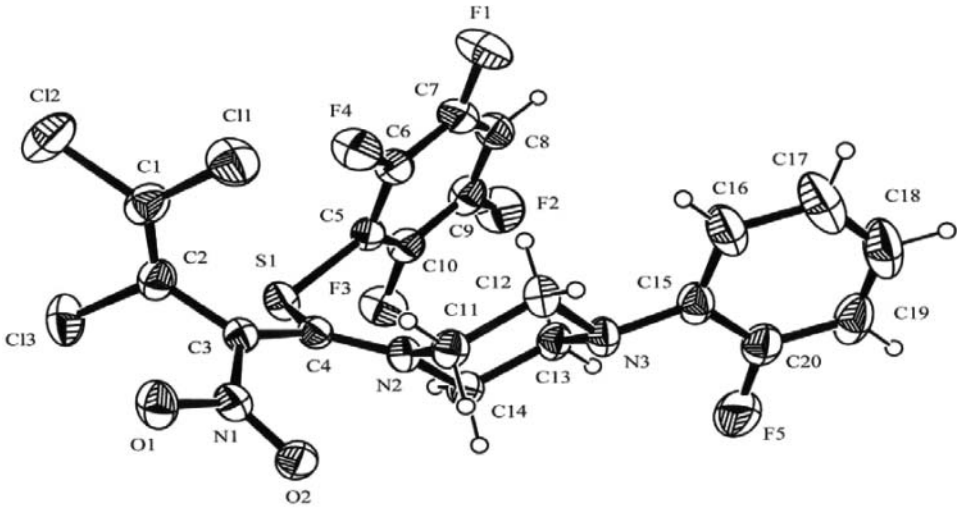


Figure 3 The molecular structure of the 8d compound. Displacement ellipsoids are drawn at the 50% probability level.

QTRAP was operated in the triple quadruple mass spectrometer mode using an electrospray ionization (ESI) source in the experiments presented here. Elemental analyses (C, H, S) were conducted using the Thermo Finnigan Flash EA 1112 elemental analyzer; their results were found to be in good agreement (±0.2%) with the calculated values. Products were isolated by column chromatography on silica gel (Fluka Silica gel 60, particle size 63–200 μm). Kieselgel 60 F-254 plates (Merck) were used for thin layer chromatography (TLC). All chemicals were reagent grade and were used without further purification. Moisture was excluded from the glass apparatus using $CaCl_2$ drying tubes.

X-Ray Structure Data Collection and Refinement

All measurements were made on a Rigaku R-Axis Rapid-S imaging plate area detector with graphite monochromated Mo-Kα radiation ($\lambda = 0.71070$ Å). The data were collected at room temperature to a maximum θ value of 30.2°. Experimental conditions are summarized in Table 1. The structure was solved by SIR92[22] and refined with CRYSTALS.[23] H atoms were treated as riding, with C–H = 0.95 (6) Å and $U_{iso}(H) = 1.2Ueq(C)$. Drawings were performed with the program ORTEP-III[24] with 30% probability displacement ellipsoids in Figures 2 and 3. Crystallographic data (excluding structure factors) for the structure reported in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. CCDC-852475 and CCDC-851960. The data and any further information can be obtained free of charge at http://www.ccdccam.ac.uk/const/retrieving.html or from the Cambridge Crystallographic Data Centre (CCDC), 12 Union Road, Cambridge CB2 1EZ, UK; fax:+44-1223-336033 or e-mail: deposit@ccdc.cam.ac.uk

General Procedure 1

Equimolar amounts of 2-nitro-pentachloro-1,3-butadiene **(1)** and thiol were stirred directly for 12–24 h at room temperature. The end of the reactions was checked by TLC.

Chloroform was added to the reaction mixture to separate the organic layer. Then, the organic layer was washed with water (4 × 30 mL) and dried with Na_2SO_4 or $MgSO_4$. After filtering, the solvent was evaporated and the residue was purified by column chromatography on silica gel or by crystallization.

General Procedure 2

Equimolar amounts of the mono(thio)substituted nitrodienes **3a**, **3b**, and *N*-nucleophiles (morpholine, piperazine, and their derivatives) were stirred for 2 to 4 h at room temperature in CH_2Cl_2. The end of the reactions was checked by TLC. $CHCl_3$ was added to the reaction mixture to separate the organic layer. Then, the organic layer was washed with water (4 × 30 mL) and dried with Na_2SO_4 or $MgSO_4$. After filtering, the solvent was evaporated and the residue was purified by column chromatography on silica gel or crystallization.

2-Nitro-1-[(4-*tert*-butylbenzyl)thio]-1,3,4,4-tetrachloro-1,3-butadiene (3a): Compound **3a** was synthesized from **1** (1.0 g, 3.72 mmol) and **2a** (0.67 g, 3.72 mmol) according to the general procedure 1. Yellow single crystals of **3a** suitable for X-ray analysis were obtained by slow evaporation of an ethanol solution. Yield: 1.46 g (95%). M.p.: 110.2–111.0 °C. R_f 0.6 (PET/$CHCl_3$ 2:1). IR: 3058 (C-$H_{arom.}$), 2866, 2964 (C-$H_{aliph.}$), 1601 (C=C), 1525, 1293 (NO_2). ^{1}H NMR: 1.24 (s, 9H, CH_3), 4.29 (s, 2H, SCH_2), 7.21–7.23 (d, J = 8.3 Hz, 2H, $H_{arom.}$), 7.31–7.33 (d, J = 8.3 Hz, 2H, $H_{arom.}$). ^{13}C NMR: 30.2 (CH_3), 33.6 (C_q-*t*-butyl), 39.7 (SCH_2), 120.3, 127.9, 137.4, 156.0 ($C_{butadien}$). $C_{15}H_{15}Cl_4NO_2S$ (415.16), calcd. C, 43.40; H, 3.64; S, 7.72; N, 3.37; found C, 43.77; H, 3.69; S, 7.03; N, 3.00.

2-Nitro-1-(2,3,5,6-tetrafluorophenylthio)-1,3,4,4-tetrachloro-1,3-butadiene (3b): Compound **3b** was synthesized from **1** (1.92g, 7.14 mmol) and **2b** (1.3 g, 7.14 mmol) according to the general procedure 1. Yellow crystals. Yield: 2.03 g (89%). M.p.: 78.0–79.0 °C. R_f 0.57 (PET/$CHCl_3$ 2:1). IR: 3084 (C-$H_{arom.}$), 1607 (C=C), 1304, 1544 (NO_2). ^{1}H NMR: 7.23–7.33 (m, 1H, $H_{arom.}$).^{13}C NMR: 109.7–110.1 (m, $CH_{arom.}$), 110.7–111.20 (t, S-$C_{arom.}$), 120.1, 130.2, 141.2,152.8 ($C_{butadien}$). $C_{10}HCl_4F_4NO_2S$ (416.84), calcd. C, 28.80; H, 0.24; S, 7.69; N, 3.36; found C, 29.49; H, 0.56; S, 7.83; N, 2.95.

4,4-Dichloro-2-nitro-1,1,3-tris[(4-*tert*-butylbenzyl)thio]-1,3-butadiene (4a): Compound **4a** was synthesized from **1** (1.0 g, 3.71 mmol) and **2a** (1.34 g, 7.42 mmol) at room temperature in the presence of NaOH in EtOH. Yellow crystals. Yield: 1.95 g (75%). M.p.: 91.1–92.0 °C. R_f 0.56 (PET/$CHCl_3$ 1:1). IR: 3027, 3055 (C-$H_{arom.}$), 2867, 2904, 2963 (C-$H_{aliph.}$), 1573, 1611 (C=C), 1310, 1535 (NO_2). ^{1}H NMR: 1.16 (s, 18H, CH_3), 1.21 (s, 9H, CH_3), 4.05 (s, 2H, SCH_2), 4.09 (s, 4H, SCH_2), 7.05–7.26 ppm (m, 12H, $H_{arom.}$). ^{13}C NMR: 30.2, 30.3 ppm (CH_3), 33.5, 33.5 (C_q-*t*-butyl), 36.3, 38.9, 39.6 (SCH_2), 124.0, 127.7, 143.4, 150.9 ($C_{butadien}$). MS (+ESI): *m/z* 701.78 $[M]^+$. $C_{37}H_{45}Cl_2NO_2S_3$ (702.86), calcd. C, 63.23; H, 6.45; S, 13.69; N, 1.99; found C, 63.36; H, 6.62; S, 12.21; N, 2.88.

1-Morpholino-2-nitro-1-[(4-*tert*-butylbenzyl)thio]-3,4,4-trichloro-1,3-butadiene (6a): Compound **6a** was synthesized from **3a** (0.1 g, 0.24 mmol) and **5** (0.022 g, 0.24 mmol) according to the general procedure 2. Yellow crystals. Yield: 0.036 g (32%). M.p.: 154.0–155.0 °C. R_f 0.35 (CH_2Cl_2). IR: 3054 (C-$H_{arom.}$), 2870, 2965 (C-$H_{aliph.}$), 1592 (C=C), 1273, 1531 (NO_2). ^{1}H NMR: 1.24 (s, 9H, CH_3), 3.33–3.63 (bs, 4H, $CH_{2morph.}$), 3.69 (s, 4H, $CH_{2morph.}$), 4.10 (s, 2H, SCH_2), 7.11–7.13 (d, J = 8.3 Hz, 2H, $H_{arom.}$), 7.28–7.30 (d, J = 8.3 Hz, 2H, $H_{arom.}$). ^{13}C NMR: 30.3 (CH_3), 33.6 (C_q-*t*-butyl), 38.9

(SCH_2), 52.6 (NCH_2), 65.4 (OCH_2), 108.8, 118.1, 124.2, 150.6 ($C_{butadien}$). MS (+ESI): *m/z* 489.84 $[M+Na]^+$. $C_{19}H_{23}Cl_3N_2O_3S$ (465.82), calcd. C, 48.99; H, 4.98; S, 6.88; N, 6.01; found C, 49.12; H, 4.59; S, 6.59; N, 6.11.

1-Morpholino-2-nitro-1-(2,3,5,6-tetrafluorophenylthio)-3,4,4-trichloro-1,3-butadiene (6b): Compound **6b** was synthesized from **3b** (0.1 g, 0.24 mmol) and **5** (0.021 g, 0.24 mmol) according to the general procedure 2. Yellow crystals. Yield: 0.097 g (86%). M.p.: 172.0–173.0 °C. R_f 0.40 (CH_2Cl_2). IR: 3058 (C-$H_{arom.}$), 2856, 2985 (C-$H_{aliph.}$), 1587, 1621 (C=C), 1276, 1537 (NO_2). ^{1}H NMR: 3.28–3.44 (bs, 2H, $CH_{2morph.}$), 3.57–3.71 (bs, 4H, $CH_{2morph.}$), 3.72–3.85 (bs, 2H, $CH_{2morph.}$), 7.11–7.18 (m, 1H, $H_{arom.}$). ^{13}C NMR: 52.7 (NCH_2), 65.2 (OCH_2), 107.5–107.8 (t, $CH_{arom.}$), 109.2–109.5 (t, $SC_{arom.}$), 120.4, 123.9, 126.1, 161.3 ($C_{butadien}$). MS (+ESI): *m/z* 490.80 $[M+Na]^+$. $C_{14}H_9Cl_3F_4N_2O_3S$ (467.65), calcd. C, 35.96; H, 1.94; S, 6.86; N, 5.99; found C, 35.46; H, 1.86; S, 7.28; N, 5.96.

1-[(2-Fluorophenyl)piperazinyl]-2-nitro-1-[(4-*tert*-butylbenzyl)thio]-3,4,4-trichloro-1,3-butadiene (8a): Compound **8a** was synthesized from **3a** (0.1 g, 0.24 mmol) and **7a** (0.04 g, 0.24 mmol) according to the general procedure 2. Yellow crystals. Yield: 0.113 g (83%). M.p.: 160.0–160.3 °C. R_f 0.53 (CH_2Cl_2). IR: 3054 (C-H_{arom}), 2862, 2961 (C-$H_{aliph.}$), 1586, 1611 (C=C), 1275, 1540 (NO_2). ^{1}H NMR: 1.24 (s, 9H, CH_3), 3.12 (s, 4H, CH_{2piper}), 3.45–3.92 (bs, 4H, CH_{2piper}), 4.12 (s, 2H, SCH_2), 6.82–6.86 (t, 1H, H_{arom}), 6.91-7.02 (m, 3H, $H_{arom.}$), 7.13–7.15 (d, J = 8.3 Hz, 2H, $H_{arom.}$), 7.28–7.31 ppm (d, J = 8.3 Hz, 2H, $H_{arom.}$), $_2$). ^{13}C NMR: 30.2 (CH_3), 33.6 (C_q-*t*-butyl), 38.9 (SCH_2), 49.4, 52.3 (NCH_2), 115.4, 115.5, 124.1, 150.5 ($C_{butad.}$), 153.7, 155.7 (F-$C_{arom.}$). MS (+ESI): *m/z* 582.63 $[M+Na]^+$. $C_{25}H_{27}Cl_3FN_3O_2S$ (558.92), calcd. C, 53.72; H, 4.87; S, 5.74; N, 7.52; found C, 53.34; H, 4.80; S, 6.12; N, 7.99.

1-[(4-Fluorophenyl)piperazinyl]-2-nitro-1-[(4-*tert*-butylbenzyl)thio]-3,4,4-trichloro-1,3-butadiene (8b): Compound **8b** was synthesized from **3a** (0.1 g, 0.24 mmol) and **7b** (0.04 g, 0.24 mmol) according to the general procedure 2. Red crystals. Yield: 0.115 g (86%). M.p.: 176.4–177.0 °C. R_f 0.50 (CH_2Cl_2). IR: 3028, 3063 (C-$H_{arom.}$), 2868, 2966 (C-$H_{aliph.}$), 1588, 1607 (C=C), 1269, 1538 (NO_2). ^{1}H NMR: 1.24 (s, 9H, CH_3), 3.12 (s, 4H, $CH_{2piper.}$), 3.48–3.79 (bs, 4H, $CH_{2piper.}$), 4.12 (s, 2H, SCH_2), 6.78–6.81 (m, 2H, $H_{arom.}$), 6.89–6.93 (t, 2H, $H_{arom.}$), 7.13–7.15 (d, J = 8.3 Hz, 2H, $H_{arom.}$), 7.29–7.30 (d, J = 8.3 Hz, 2H, $H_{arom.}$). ^{13}C NMR: 30.3 (CH_3), 33.6 (C_q-*t*-butyl), 38.9 (SCH_2), 49.5, 52.0 (NCH_2), 124.2, 128.1, 145.6, 150.6 ($C_{butadien}$), 157.9, 156.0 (F-$C_{arom.}$). MS (+ESI): *m/z* 582.48 $[M+Na]^+$. $C_{25}H_{27}Cl_3FN_3O_2S$ (558.92), calcd. C, 53.72; H, 4.87; S, 5.74; N, 7.52; found C, 53.98; H, 5.00; S, 7.45; N, 7.39.

1-(*N*-Methylpiperazinyl)-2-nitro-1-[(4-*tert*-butylbenzyl)thio]-3,4,4-trichloro-1, 3-butadiene (8c): Compound **8c** was synthesized from **3a** (0.1 g, 0.24 mmol) and **7c** (0.024 g, 0.24 mmol) according to the general procedure 2. Yellow crystals. Yield: 0.08 g (69%). M.p.: 125.4–126.3 °C. R_f 0.60 (MeOH). IR: 3026, 3054 C-$H_{arom.}$), 2801, 2870, 2966 (C-$H_{aliph.}$), 1591 (C=C), 1275, 1534 (NO_2). ^{1}H NMR: 1.24 (s, 9H, CH_3), 2.25 (s, 3H, NCH_3), 2.44 (s, 4H, $CH_{2\ piperazine}$), 3.36–3.68 (bs, 4H, $CH_{2piper.}$), 4.09 (s, 2H, SCH_2), 7.12–7.13 (d, J = 8.3 Hz, 2H, $H_{arom.}$), 7.28–7.29 ppm (d, J = 8.3 Hz, 2H, $H_{arom.}$). ^{13}C NMR: 26.2, 26.4 ppm (CH_3), 29.7 (NCH_3), 34.9 (C_q-*t*-butyl), 40.6, 40.7 (SCH_2), 48.2, 49.7 (NCH_2), 113.8, 119.94, 146.5, 162.9 ($C_{butadiene}$). MS (+ESI): *m/z* 478.35 $[M]^+$. $C_{20}H_{26}Cl_3N_3O_2S$ (478.86), calcd. C, 50.16; H, 5.47; S, 6.70; N, 8.77; found C, 50.22; H, 5.11; S, 7.22; N, 8.46.

1-[(2-Fluorophenyl)piperazinyl]-2-nitro-1-(2,3,5,6-tetrafluorophenylthio)-3,4,4-trichloro-1,3-butadien (8d): Compound **8d** was synthesized from **3b** (0.1 g, 0.24 mmol) and **7a** (0.04 g, 0.24 mmol) according to the general procedure 2. Orange single crystals

of **8d** suitable for X-ray analysis were obtained by slow evaporation of an ethanol solution. Yield: 0.06 g (44%). M.p.: 176.4–177.0 °C. R_f 0.56 ($CHCl_3$). IR: 3054 C-$H_{arom.}$), 2862, 2963 (C-$H_{aliph.}$), 1590, 1627 (C=C), 1267, 1537 (NO_2). ^{1}H NMR: 2.80–3.26 (bs, 4H, $CH_{2\ piperazine.}$), 3.39–3.65 (bs, 2H, $CH_{2\ piperazine.}$), 3.76–4.14 (bs, 2H, $CH_{2\ piperazine.}$), 6.80–6.86 (t, 1H, $H_{arom.}$), 6.91–7.04 (m, 3H, $H_{arom.}$), 7.08–7.17 (m, 1H, $H_{arom.}$). ^{13}C NMR: 49.3, 52.5 (NCH_2), 108.5–109.0 (t, $CH_{arom.}$), 110.0 ($SC_{arom.}$), 118.5 (d, $CH_{arom.}$), 121.8, 124.0, 126.1, 162.2 ($C_{butadiene}$). MS (+ESI): *m/z* 584.28 $[M+Na]^+$. $C_{20}H_{13}Cl_3F_5N_3O_2S$ (560.75), calcd. C,42.84; H, 2.34; S, 5.72; N, 7.49; found C, 42.51; H, 2.12; S, 6.28; N, 7.63.

1-[(4-Fluorophenyl)piperazinyl]-2-nitro-1-(2,3,5,6-tetrafluorophenylthio)-3,4,4-trichloro-1,3-butadiene (8e): Compound **8e** was synthesized from **3b** (0.1 g, 0.24 mmol) and **7b** (0.04 g, 0.24 mmol) according to the general procedure 2. Orange crystals. Yield: 0.072 g (53%). M.p.: 177.1–178.0 °C. R_f 0.5($CHCl_3$). IR: 3056 (C-$H_{arom.}$), 2840, 2919 (C-$H_{aliph.}$), 1595, 1631 (C=C), 1279, 1559 (NO_2). ^{1}H NMR: 2.88–3.24 (bs, 4H, $CH_{2\ piperazine.}$), 3.37–3.63 (bs, 2H, $CH_{2\ piperazine.}$), 3.80–4.11 (bs, 2H, $CH_{2\ piperazine.}$), 6.76–6.84 (m, 2H, $H_{arom.}$), 6.90–6.97 (m, 2H, $H_{arom.}$), 7.08–7.17 (m, 1H, $H_{arom.}$). ^{13}C NMR: 49.5, 52.3 (NCH_2), 107.3–107.8 (t, $CH_{arom.}$), 109.4 ($SC_{arom.}$), 114.9, 115.0 ($CH_{arom.}$), 117.8–117.9 (d, $CH_{arom.}$), 120.8, 123.9, 126.1, 161.3 ($C_{butadiene}$). MS (+ESI): *m/z* 560.09 $[M]^+$. $C_{20}H_{13}Cl_3F_5N_3O_2S$ (560.75), calcd. C, 42.84; H, 2.34; S, 5.72; N, 7.49; found C, 42.63; H, 2.37; S, 5.74; N, 7.61.

1-(*N*-Methylpiperazinyl)-2-nitro-1-(2,3,5,6-tetrafluorophenylthio)-3,4,4-trichloro-1,3-butadiene (8f): Compound **8f** was synthesized from **3b** (0.1 g, 0.24 mmol) and **7c** (0.024 g, 0.24 mmol) according to the general procedure 2. Yellow crystals. Yield: 0.71 g (61%). M.p.: 119.2–120.0 °C. R_f 0.40 (CH_2Cl_2/EtAc 1:1). IR: 3052 (C-$H_{arom.}$), 2812, 2962 (C-$H_{aliph.}$), 1585, 1629 (C=C), 1274, 1539 (NO_2). ^{1}H NMR: 2.05–2.60 (bs, 4H, $CH_{2piper.}$), 2.26 (s, 3H, CH_3), 3.23–3.51 (bs, 2H, $CH_{2piper.}$), 3.64–3.95 (bs, 2H, $CH_{2piper.}$), 7.09–7.16 (m, 1H, $H_{arom.}$). ^{13}C NMR: 44.6 (NCH_3), 52.3, 53.5 (NCH_2), 107.3–107.6 (t, $CH_{arom.}$), 109.5 ($SC_{arom.}$), 120.2, 124.1, 125.9, 161.3 ($C_{butadiene}$). MS (+ESI): *m/z* 503.86 $[M+Na]^+$. $C_{15}H_{12}Cl_3F_4N_3O_2S$ (480.69), calcd. C, 37.48; H, 2.52; S, 6.67; N, 8.74; found C, 37.27; H, 2.48; S, 6.67; N, 8.61.

***N*,*N*-Bis[2-nitro-1-[(4-*tert*-butylbenzyl)thio]-3,4,4-trichloro-1,3-butadienyl]-2,5-dimethylpiperazine (10a)**: Compound **10a** was synthesized from **3a** (0.1 g, 0.24 mmol) and **9** (0.027 g, 0.24 mmol) according to the general procedure 2. Yellow crystals. Yield: 0.71 g (81%). M.p.: 226.0°C. R_f 0.62 (CH_2Cl_2). IR: 3027, 3056 (C-$H_{arom.}$), 2868, 2906, 2963 (C-$H_{aliph.}$), 1587, 1663 (C=C), 1272, 1516 (NO_2). ^{1}H NMR: 1.20 (s, 24H, CH_3), 2.44–2.67 (bs, 2H, $CH_{piper.}$), 3.65–3.78 (bs, 2H, $CH_{2piper.}$), 3.65–3.78 (bs, 2H, CH_{2piper}), 4.19–4.38 (bs, 2H, SCH_2), 4.43–4.63 (bs, 2H, SCH_2), 7.09–7.10 (d, J = 8.3 Hz, 4H, $H_{arom.}$), 7.25–7.27 (d, J = 8.3 Hz, 4H, $H_{arom.}$). MS (+ESI): *m/z* 893.00 $[M+Na]^+$. $C_{36}H_{42}Cl_6N_4O_4S_2$ (871.59), calcd. C, 49.61; H, 4.86; S, 7.36; N, 6.43; found C, 49.93; H, 4.53; S, 7.33; N, 6.29.

***N*,*N*-Bis[2-nitro-1-[(4-*tert*-butylbenzyl)thio]-3,4,4-trichloro-1,3-butadienyl]-piperazine (12a)**: Compound **12a** was synthesized from **3a** (0.1 g, 0.24 mmol) and **11** (0.021 g, 0.24 mmol) according to the general procedure 2. Yellow crystals. Yield: 0.093 g (46%). M.p.: 228.0–228.6 °C. R_f 0.4 (CH_2Cl_2). IR: 3054 (C-$H_{arom.}$), 2868, 2963 (C-$H_{aliph.}$), 1601 (C=C), 1278, 1537 (NO_2). ^{1}H NMR: 1.23 (s, 18H, CH_3), 3.04–3.50 (bs, 4H, $CH_{2\ piperazine.}$), 3.51–3.85 (bs, 4H, $CH_{2\ piperazine.}$), 3.87–4.25 (bs, 4H, SCH_2), 7.09–7.11 (d, J = 8.3 Hz, 4H, $H_{arom.}$), 7.28–7.29 ppm (d, J = 8.3 Hz, 4H, $H_{arom.}$), ^{13}C NMR: 29.9, 31.5 (CH_3), 34.9 (C_q-*t*-butyl), 40.3 (SCH_2), 51.7 (NCH_2), 110.0, 121.4, 126.2,

152.0 ($C_{butadiene}$). MS (+ESI): *m/z* 864.86 $[M+Na]^+$. $C_{34}H_{38}Cl_6N_4O_4S_2$ (843.54), calcd. C,48.41; H, 4.54; S, 7.60; N, 6.64; found: C, 48.81; H, 4.53; S, 6.24; N, 6.70.

1-(2-Aminophenylthio)-1,2,3,4,4-pentachloro-1,3-butadiene (14): Compound **14** was synthesized from of **13** (2 g, 7.75 mmol) and *o*-aminothiophenol (1.94 g, 15.5 mmol) at room temperature in the presence of NaOH in EtOH. Brown crystals. Yield: 0.66 g (24%). M.p.: 46.5–47.0 °C. R_f 0.84 (PET/$CHCl_3$ 1:1). IR: 3020, 3068 (C-$H_{arom.}$), 1545, 1610 (C=C), 3382, 3478 (NH_2). ^{1}H NMR: 4.17 (s, 2H, NH_2), 6.64–6.68 (m, 2H, $H_{arom.}$), 7.15–7.20 (t, J = 7.32 Hz, 1H, $H_{arom.}$), 7.29–7.31 (dd, J_1 = 7.81 Hz, J_2 = 1.47 Hz, 1H, H_{arom}). ^{13}C NMR: 120.6, 125.2, 126.0, 134.4 ($C_{butadiene.}$). MS (+ESI): *m/z* 349.86 $[M+H]^+$, MS/MS (+ESI): *m/z* 313.89 (M-Cl). $C_{10}H_6Cl_5N$ (349.49), calcd. C, 34.37; H, 1.73; S, 9.17; N, 4.01; found C, 34.57; H, 1.93; S, 10.28; N, 3.94.

1,4-Bis(2-aminophenylthio)-1,2,3,4-tetrachloro-1,3-butadiene (15): Compound **15** was synthesized from **13** (2 g, 7.75 mmol) and *o*-aminothiophenol (1.94 g, 15.5 mmol) at room temperature in the presence of NaOH in EtOH. Yellow Oil. Yield: 1.60 g (47%). R_f 0.59 (PET/$CHCl_3$ 1:1). IR: 3019, 3064 (C-$H_{arom.}$), 1533, 1609 (C=C), 3379, 3475 (NH_2). ^{1}H NMR: 3.80–4.55 (bs, 4H, NH_2), 6.54–6.70 (m, 4H, $H_{arom.}$), 7.07–7.20 (m, 3H, $H_{arom.}$), 7.36–7.47 (dd, J_1 = 7.81 Hz, J_2 = 1,46 Hz, 1H, $H_{arom.}$). MS (+ESI): *m/z* 439.26 $[M+H]^+$, MS/MS (+ESI): *m/z* 402.88 (M-Cl). $C_{16}H_{12}Cl_4N_2S_2$ (438.22), calcd. C, 43.85; H, 2.76; S, 14.63; N, 6.39; found C, 43.99; H, 2.61; S, 12.88; N, 6.18.

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