Supplementary Material

N-methylthiomethylation of benzimidazoles with DMSO and their chemoselective oxidation to sulfoxides with $NaBiO_3$

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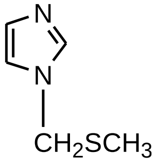
1. Materials and Methods

All solvents were dried by standard methods. Unless otherwise specified, chemicals were purchased from commercial suppliers and used without further purification. Benzimidazoles were synthesized following one of our previous work.[1] Column chromatography was performed on silica gel (60-120 mesh). TLC was done on glass sheets pre-coated with silica gel (with binder, 300 mesh, Merck). The ^{1}H- and ^{13}C-NMR spectra were taken in $CDCl_3$ with TMS as an internal reference and in some cases d_6 - DMSO. The chemical shifts were reported as δ values (ppm) relative to TMS. IR spectra were recorded in KBr pellets. Ion cyclotron resonance Fourier transform HRMS was performed on a Micromass ZQ instrument (Waters) (location: Indian Institute of Chemical Biology, 4, Raja S. C. Mullick Road, Kolkata-700032) and ESIMS of the compounds were recorded on a Waters LC-MS-MS (quattro micro mass) instrument (Chemgen Pharma International Pvt. Ltd., Dr. Siemens Street, Block GP, Sector-V, Salt Lake City, Kolkata-700091).

Compounds **2a**,[2] **2b**,[2] **2c**,[2] **2d**[2] are known in the literature and thus spectroscopic data elemental analysis data and ^{13}C NMR spectra are not given. Only ^{1}H NMR data are given below.

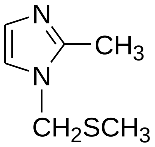
2. Analytical Data of Known Compounds

Compound (2a) (Table 2, entry 1)



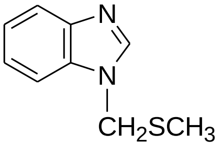
Characteristic. Colorless oil.
^{1}H NMR (300 MHz, $CDCl_3$): δ 2.03 (s, 3H), 4.93 (s, 2H), 7.08 (d, J = 7.2 Hz, 2H), 7.72(s, 1H).

Compound (2b) (Table 2, entry 2)



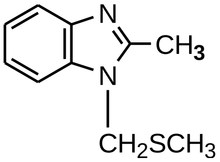
Characteristic. Colorless oil.
^{1}H NMR (300 MHz, $CDCl_3$): δ 2.07 (s, 3H), 2.47 (s, 3H), 4.85 (s, 2H), 6.96 (br.d, J = 6.3 Hz, 1H), 7.71 (br.d, J = 6.3 Hz,1H).

Compound (2c) (Table 2, entry 3)



Characteristic. Colorless oil.
^{1}H NMR (300 MHz, $CDCl_3$): δ 2.05 (s, 3H), 5.22 (s, 2H), 7.37-7.26 (m, 2H), 7.54 (br.d, J = 4.8 Hz, 1H), 7.85 (s, 1H), 8.01 (br.d, J = 4.8 Hz, 1H).

Compound (2d) (Table 2, entry 4)

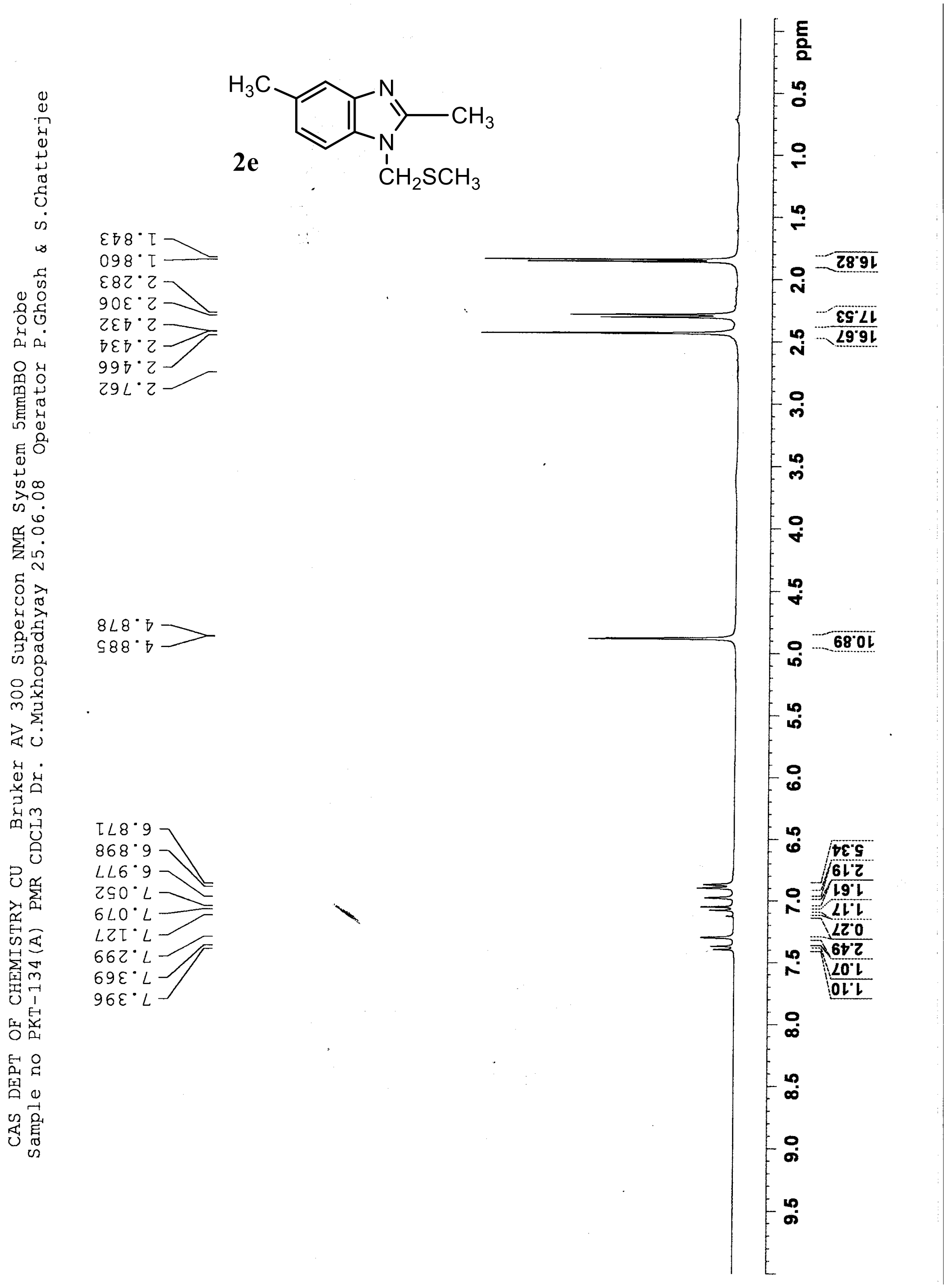


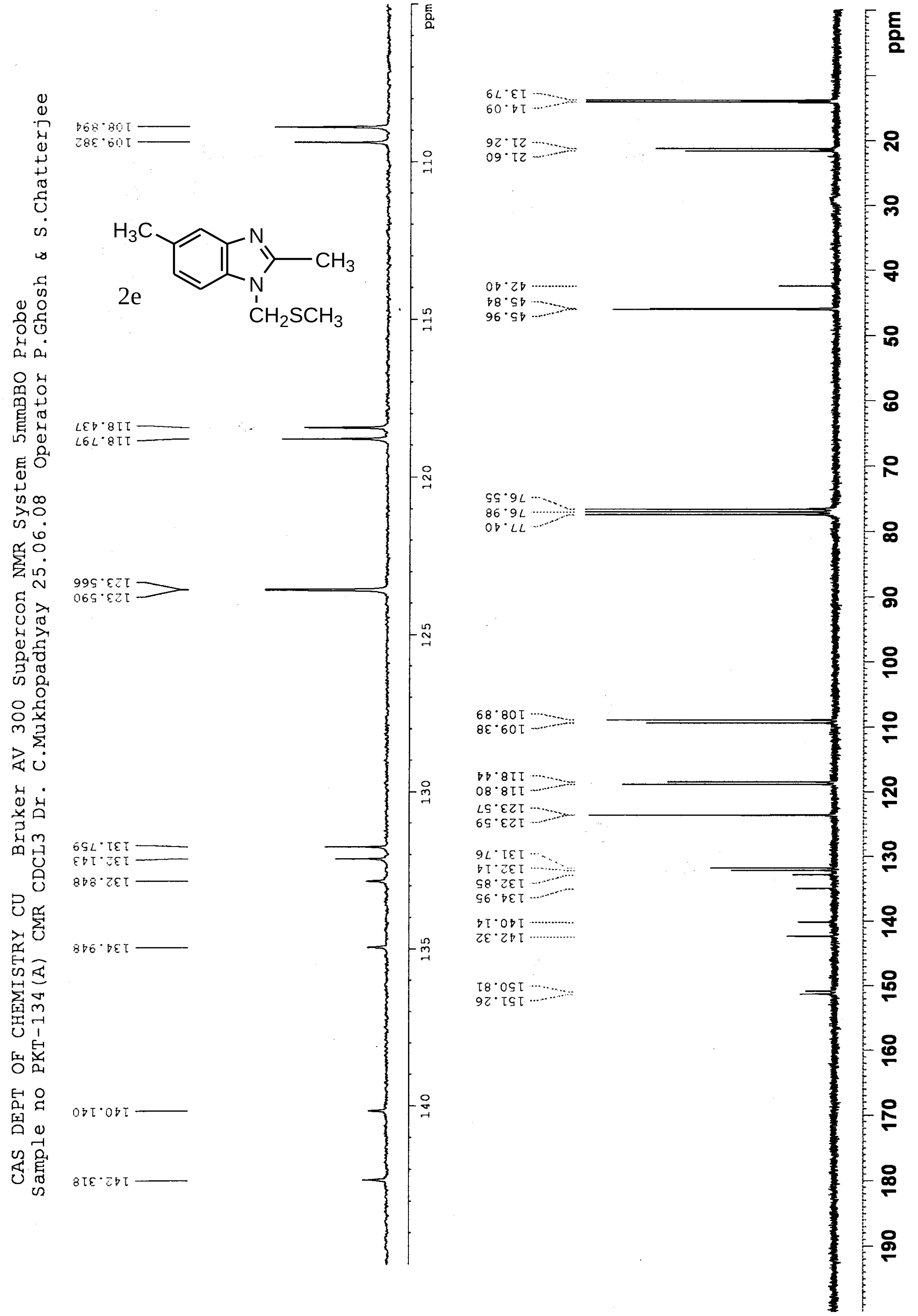
Characteristic. Colorless semisolid.
^{1}H NMR (300 MHz, $CDCl_3$): δ 1.98 (s, 3H), 2.59 (s, 3H), 5.04 (s, 2H), 7.22 – 7.18 (m, 2H), 7.33 – 7.30 (m, 1H) 7.70 – 7.62 (m, 1H).

3. References

1. Mukhopadhyay, C.; Tapaswi, P. K. *Tetrahedron Lett.* **2008**, *49*, 6237.
2. (a) Janzen, A. F.; Lypka, G. N.; Wasylishen, R. E. *Canadian J Chem*. **1980**, *58*, 60. (b) Janzen, A. F.; Lypka, G. N.; Wasylishen, R. E. *J Heter*. *Chem.* **1979**, *16*, 415.

4. NMR of compounds (2e), (2f), (3a), (3b)

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Sample no PKT-134(A) CMR CDCL3 Dr. C.Mukhopadhyay 25.06.08 Operator P.Ghosh & S.Chatterjee
H3C
N
CH3
N
CH2SCH3
2e
108.894
109.382
118.437
118.797
123.566
123.590
131.759
132.143
132.848
134.948
140.140
142.318
110
115
120
125
130
135
140
ppm
13.79
14.09
21.26
21.60
42.40
45.84
45.96
76.55
76.98
77.40
108.89
109.38
118.44
118.80
123.57
123.59
131.76
132.14
132.85
134.95
140.14
142.32
150.81
151.26
20
30
40
50
60
70
80
90
100
110
120
130
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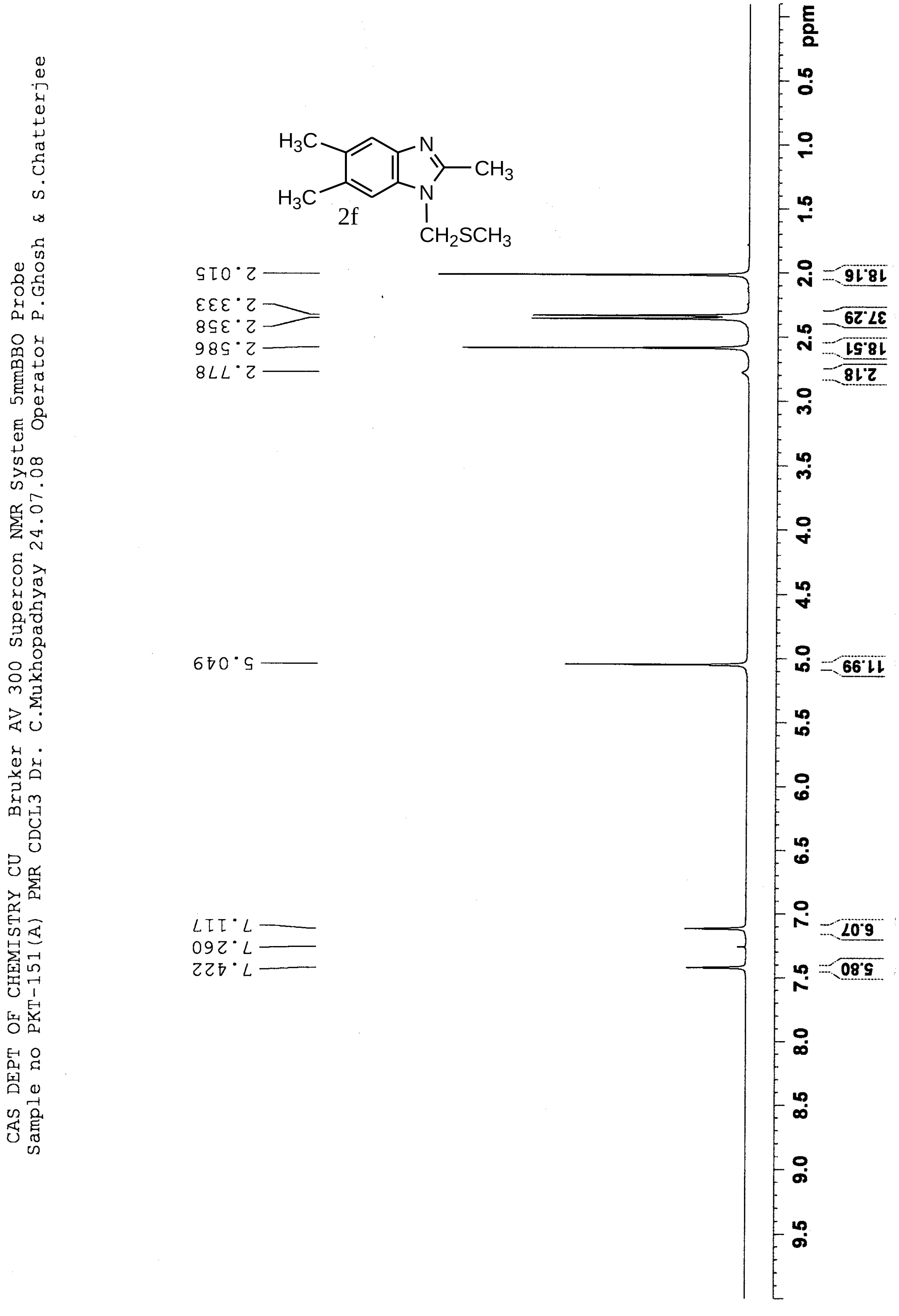
150
160
170
180
190
ppm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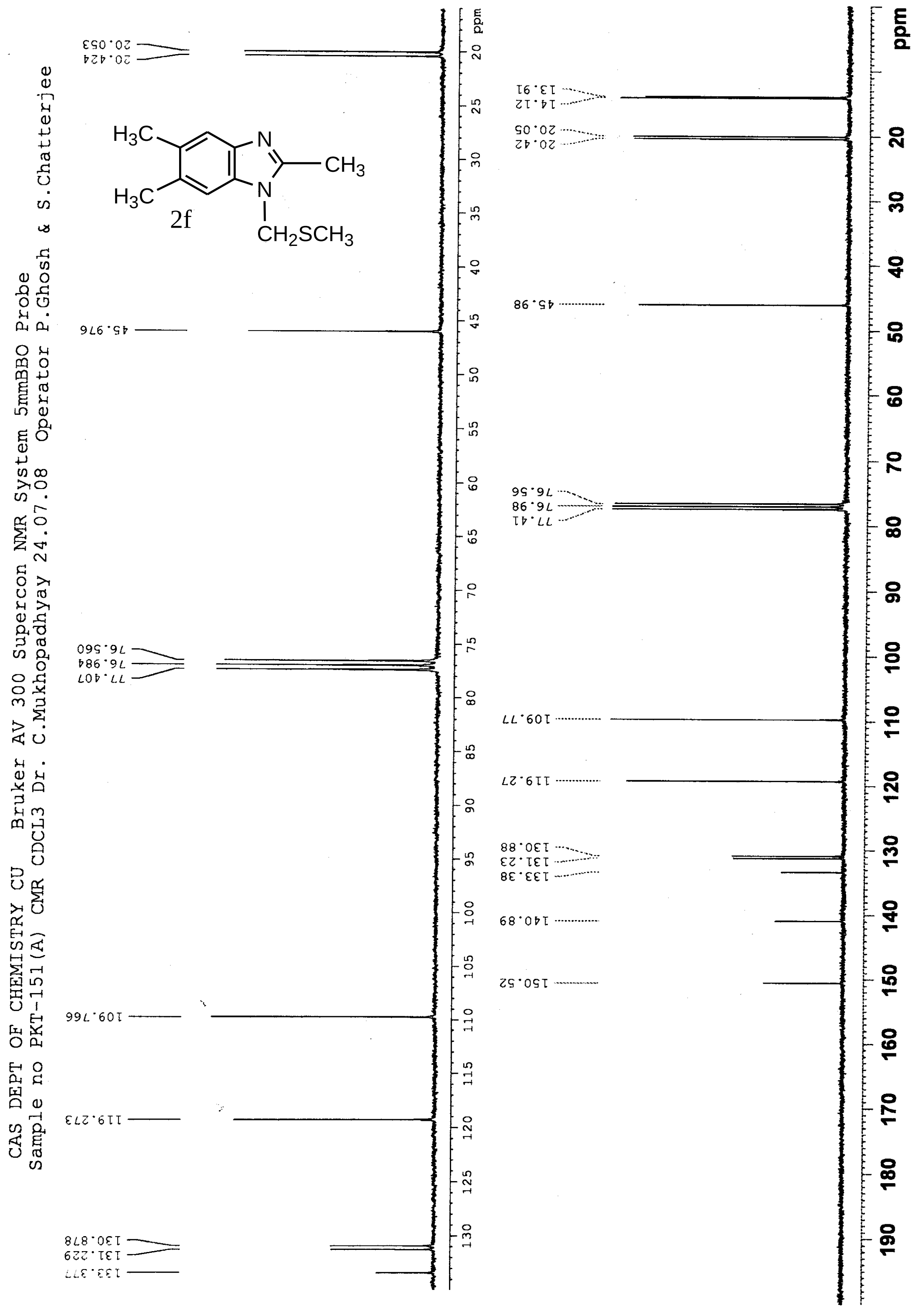
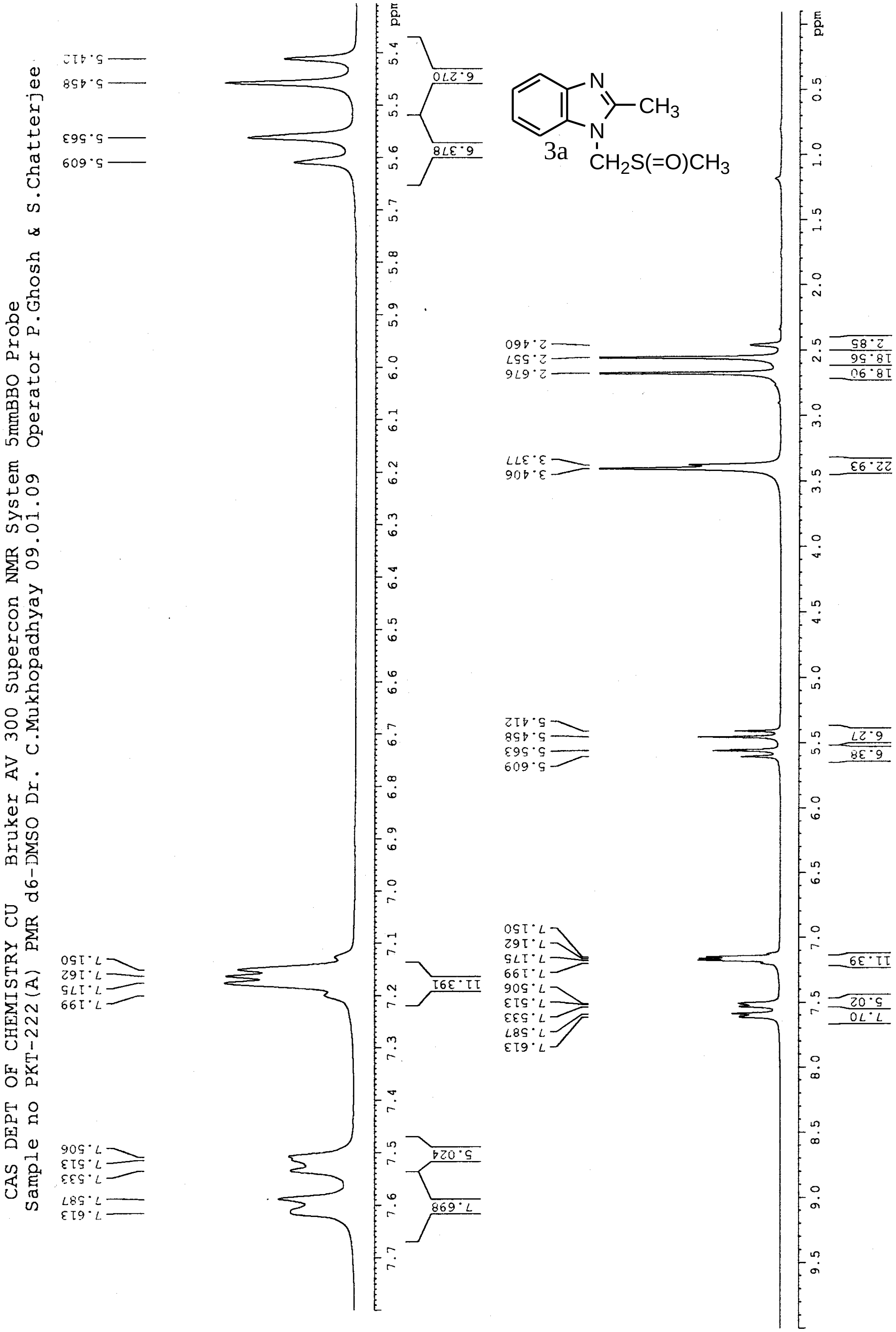
Sample no PKT-151(A) PMR CDCL3 Dr. C.Mukhopadhyay 24.07.08 Operator P.Ghosh & S.Chatterjee
H3C
H3C
N
N
CH3
CH2SCH3
2f
2.015
2.333
2.358
2.586
2.778
5.049
7.117
7.260
7.422
18.16
37.29
18.51
2.18
11.99
6.07
5.80
ppm
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5


CAS DEPT OF CHEMISTRY CU Bruker AV 300 Supercon NMR System 5mmBBO Probe
Sample no PKT-151(A) CMR CDCL3 Dr. C.Mukhopadhyay 24.07.08 Operator P.Ghosh & S.Chatterjee
H3C
H3C
N
N
CH3
CH2SCH3
2f
20.053
20.424
45.976
76.560
76.984
77.407
109.766
119.273
130.878
131.229
133.377
ppm
13.91
14.12
20.05
20.42
45.98
76.56
76.98
77.41
109.77
119.27
130.88
131.23
133.38
140.89
150.52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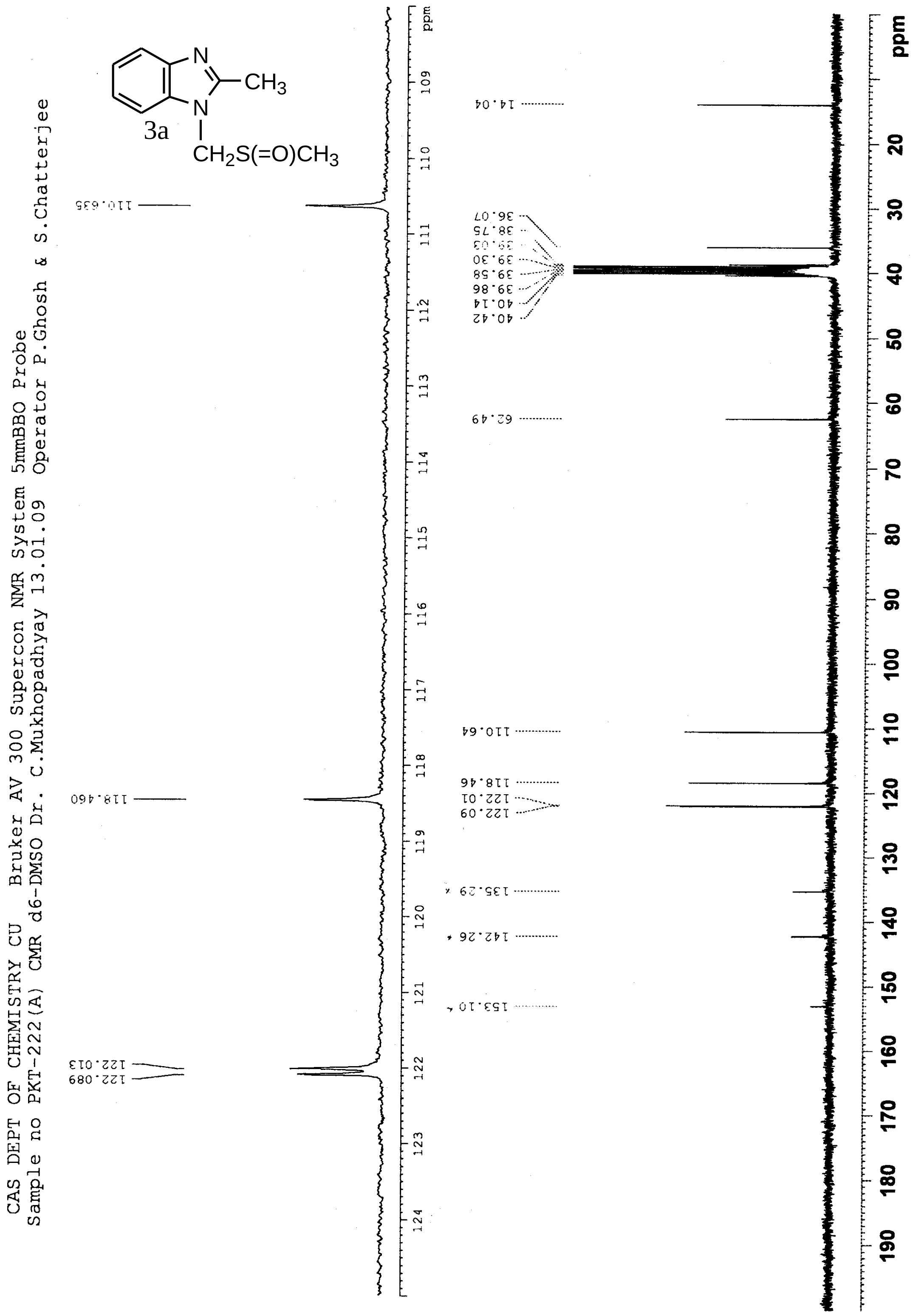
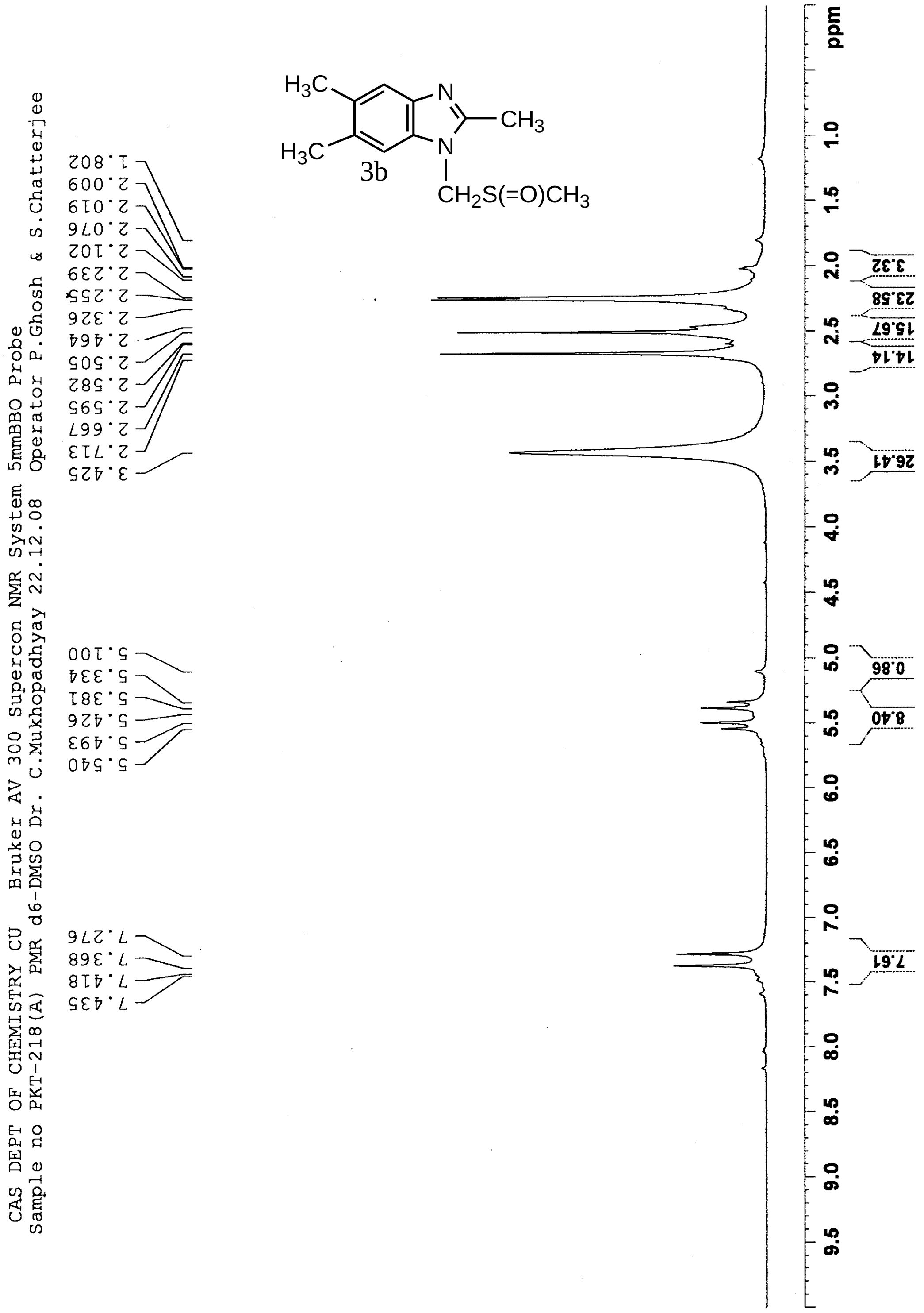
Sample no PKT-222(A) PMR d6-DMSO Dr. C.Mukhopadhyay 09.01.09 Operator P.Ghosh & S.Chatterjee
5.412
5.458
5.563
5.609
6.270
6.378
7.150
7.162
7.175
7.199
11.391
7.506
7.513
7.533
7.587
7.613
5.024
7.698
ppm
N
CH3
N
CH2S(=O)CH3
3a
2.460
2.557
2.676
3.377
3.406
2.85
18.56
18.90
22.93
6.27
6.38
11.39
5.02
7.70


CAS DEPT OF CHEMISTRY CU Bruker AV 300 Supercon NMR System 5mmBBO Probe
Sample no PKT-222(A) CMR d6-DMSO Dr. C.Mukhopadhyay 13.01.09 Operator P.Ghosh & S.Chatterjee
3a
N
N
CH3
CH2S(=O)CH3
110.635
118.460
122.013
122.089
ppm
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
14.04
36.07
38.75
39.03
39.30
39.58
39.86
40.14
40.42
62.49
110.64
118.46
122.01
122.09
135.29
142.26
153.10
ppm
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190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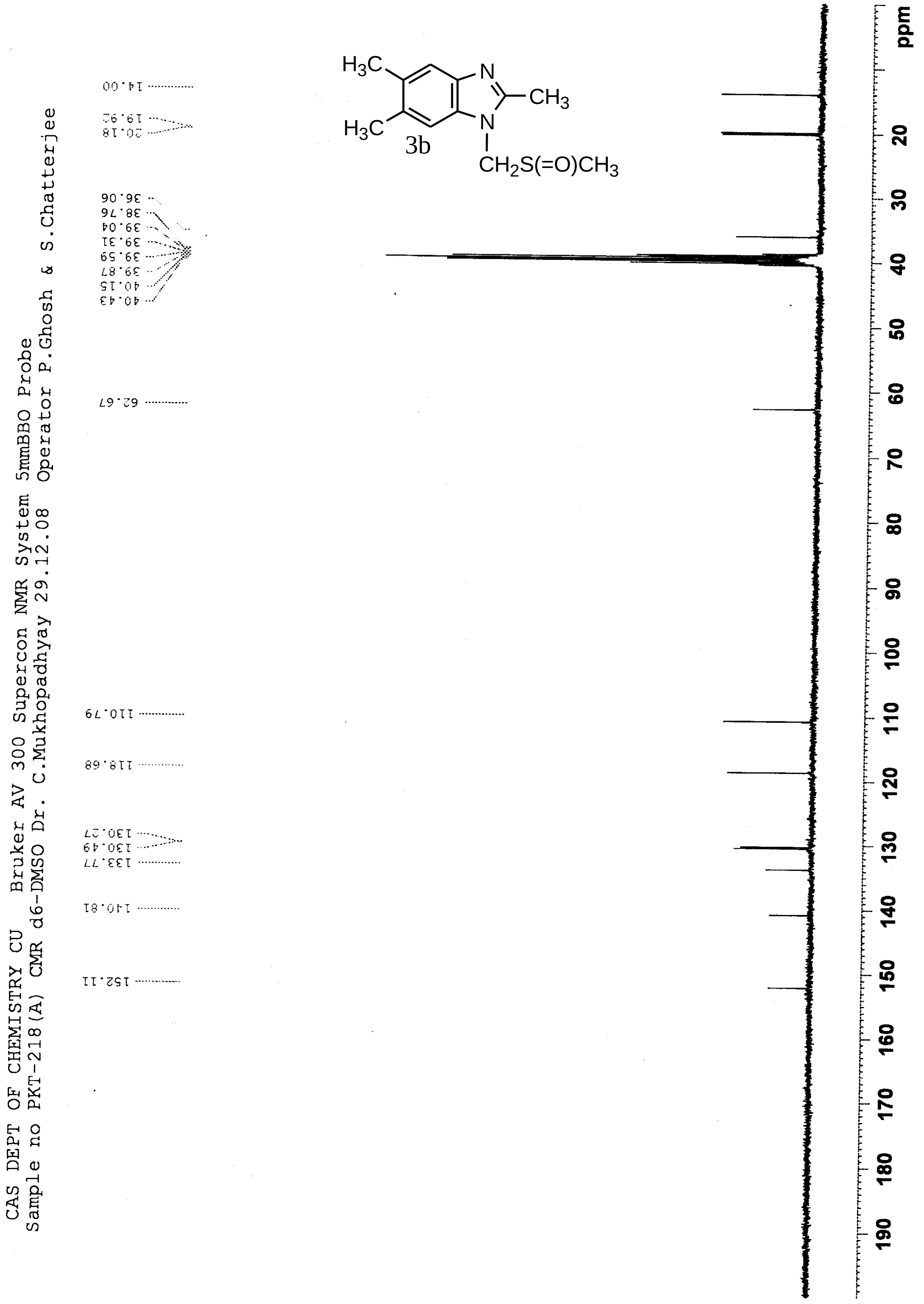
Sample no PKT-218(A) PMR d6-DMSO Dr. C.Mukhopadhyay 22.12.08 Operator P.Ghosh & S.Chatterjee
7.435
7.418
7.368
7.276
5.540
5.493
5.426
5.381
5.334
5.100
3.425
2.713
2.667
2.595
2.582
2.505
2.464
2.326
2.255
2.239
2.102
2.076
2.019
2.009
1.802
H3C
H3C
N
N
CH3
CH2S(=O)CH3
7.61
8.40
0.86
26.41
14.14
15.67
23.58
3.32
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm

3b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Sample no PKT-218(A) CMR d6-DMSO Dr. C.Mukhopadhyay 29.12.08 Operator P.Ghosh & S.Chatterjee
14.00
19.92
20.18
36.06
38.76
39.04
39.31
39.59
39.87
40.15
40.43
62.67
110.79
118.68
130.27
130.49
133.77
140.81
152.11
H_3C
H_3C
N
N
CH_3
3b
$CH_2S(=O)CH_3$
ppm
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

5. Information regarding crystallographic studies on Figure 1 and Figure 2 in the manuscript

Crystal data, Figure 1, C15H14N2S, M = 254.34, monoclinic, spacegroup $P2_1/c$, Z = 4, a = 11.8986(7), b = 7.7364(3), c = 14.0305(8)Å, β = 95.129(6)°, V = 1286.37(12)Å^3, dcalc = 1.313 gcm^{-3}
Crystal data, Figure 2, C30.5H37N4O6S2, M = 619.76, monoclinic, spacegroup $P2_1/n$, Z = 4, a = 20.4771(9), b = 7.3488(2), c = 21.1873(17)Å, β = 108.114(6)°, V = 3030.3(3)Å^3, dcalc = 1.358 gcm^{-3}
3714, 8759 independent reflection data were collected with MoKα radiation at 150K using the Oxford Diffraction X-Calibur CCD System. The crystals were positioned at 50 mm from the CCD. 321 frames were measured with a counting time of 10s. Data analyses were carried out with the CrysAlis program.[1] The structures were solved using direct methods with the Shelxs97 program.[2] The non-hydrogen atoms were refined with anisotropic thermal parameters. The hydrogen atoms bonded to carbon were included in geometric positions and given thermal parameters equivalent to 1.2 times those of the atom to which they were attached. In 2, there were two water molecules refined with full occupancy. The hydrogen atoms were located in a difference Fourier map and refined with distance constraints. Three water molecules were also located with reduced occupancy (70, 30, 50% respectively) but their hydrogens could not be located. One methanol molecule was also located and refined with 50% occupancy.
The structures were refined on F^2 using Shelxl97[2] to R1 0.0400, 0.0788; wR2 0.0942, 0.2130 for 2544, 5921 data with $I>2\sigma(I)$.

The structure of Figure 2 contains 2 molecules in the asymmetric unit together with five water molecules, three of which have reduced occupancy and one methanol, also with reduced occupancy. The two molecules in the asymmetric unit have similar geometries as is apparent from figure 2.
In particular the angles around the N1-C and C-S11 bonds are 109.1(3) in A, -106.2(3) in B and -69.9(2) in A, 74.2(2)° in B respectively thus showing that the molecules are opposite enantiomers.
The phenyl rings in the two structures of Figure 2 stack with the six C...C distances ranging from 3.54 to 3.75Å. The angle between the two phenyl ring planes is 2.3(1)°.

References

1. CrysAlis, (2006) Oxford Diffraction Ltd., Abingdon, U.K.
2. G. M. Sheldrick, Shelxs97 and Shelxl97, Programs for Crystallographic solution and refinement, Acta Cryst. 2008 A64 112.