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Short Report

Three New Compounds from *Piper montealegreanum* Yuncker (Piperaceae)

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Três novos compostos: dois flavonóides [(*S*)-8-formil-3',5-diidroxi-7-metoxi-6-metilflavanona (**1**) e 3'-formil-3,4',6'-triidroxi-2'-metoxi-5'-metilchalcona (**2**)] e um fenilpropanóide [3,4-metilenodioxi-5-metoxi-7,8-diidrocinamato de etila (**3**)] foram isolados dos ramos secos de *Piper montealegreanum*. As estruturas desses compostos foram estabelecidas através das técnicas espectroscópicas UV, IV, EM e RMN (^{1}H e ^{13}C, 1D e 2D), além da interpretação dos dados de RMN de ^{1}H e ^{13}C dos derivados metilados dos compostos **1** e **2**.

Three new compounds: two flavonoids [(*S*)-8-formyl-3',5-dihydroxy-7-methoxy-6-methylflavanone (**1**) and 3'-formyl-3,4',6'-trihydroxy-2'-methoxy-5'-methylchalcone (**2**)] and one phenylpropanoid [ethyl 3,4-methylenedioxy-5-methoxy-7,8-dihydrocinnamate (**3**)] were isolated from dried branches of *Piper montealegreanum*. Their structures were established by UV, IR, MS, 1D and 2D (^{1}H and ^{13}C) NMR spectroscopic techniques, besides interpretation of spectral data (^{1}H and ^{13}C NMR) of methylated derivatives of **1** and **2** compounds.

Keywords: *Piper montealegreanum*, flavanone, chalcone, phenylalcanoid

Introduction

Piper montealegreanum Yuncker (Piperaceae) is a shrub, native to the north Brazil[1] and has no previous chemical studies reported. A continuing search on the chemistry and bioactive agents from Brazilian north-northeast Piperaceae species have resulted in the isolation of amides,[2-5] aristolactams[6,7] and propenylphenols.[8-12] In this paper, we report the isolation and structure elucidation of (*S*)-8-formyl-3',5-dihydroxy-7-methoxy-6-methylflavanone (**1**), 3'-formyl-3,4',6'-trihydroxy-2'-methoxy-5'-methylchalcone (**2**), and ethyl 3,4-methylenedioxy-5-methoxy-7,8-dihydrocinnamate (**3**) from the branches of *P. montealegreanum* (Figure 1). The structures of the compounds were determined by interpretation of the spectral data analysis of UV, IR, MS, ^{1}H and ^{13}C NMR, including 2D NMR HMQC (heteronuclear multiple quantum coherence), HMBC (heteronuclear multiple bond correlation), and by comparison with those reported in the literature.[13]

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Results and Discussion

Compound **1** was obtained as orange-yellow crystals. The MS spectrum presented a molecular ion peak at *m/z* 327.0887 $(M-1)^-$, in LC-MS-IT-TOF apparatus (ion trap-time of flight liquid chromatography mass spectrometry). The ^{1}H NMR spectrum showed the presence of four singlets at δ_H 12.63 (1H), 10.15 (1H), 3.99 (3H) and 2.05 (3H) consistent with the presence of chelated hydroxyls, aldehyde, methoxyl and methyl groups, respectively. The presence of three signals at δ_H, 5.43 (dd,1H, *J* 10.8 and 4.6 Hz), 2.97 (dd, 1H, *J* 17.0 and 10.8 Hz), 2.85 (dd,1H, *J* 4.6 and 17.0 Hz), and also signals for four coupled aromatic protons at δ_H, 7.26 (t, 1H, *J* 8.0 Hz), 6.85 (brd, 1H, *J* 8.0 Hz) and 6.93 (m, 2H), suggested a flavanone nucleus[14] with a 3'-monosubstituted B ring, deduced by analysis of the multiplicity and coupling constants of the aromatic protons.[15] The above data and UV spectrum, with λ_{max} at 266 nm, reinforced a flavanone nature for compound **1**.[13] Since no further aromatic protons were evident, ring A should be fully substituted. The presence of the signal to methine carbon at δ_C 193.8 in the ^{13}C NMR APT (attached proton test) spectrum was taken as a proof for the presence of an aldehyde group, and the low-field hydroxyl hydrogen [δ_H

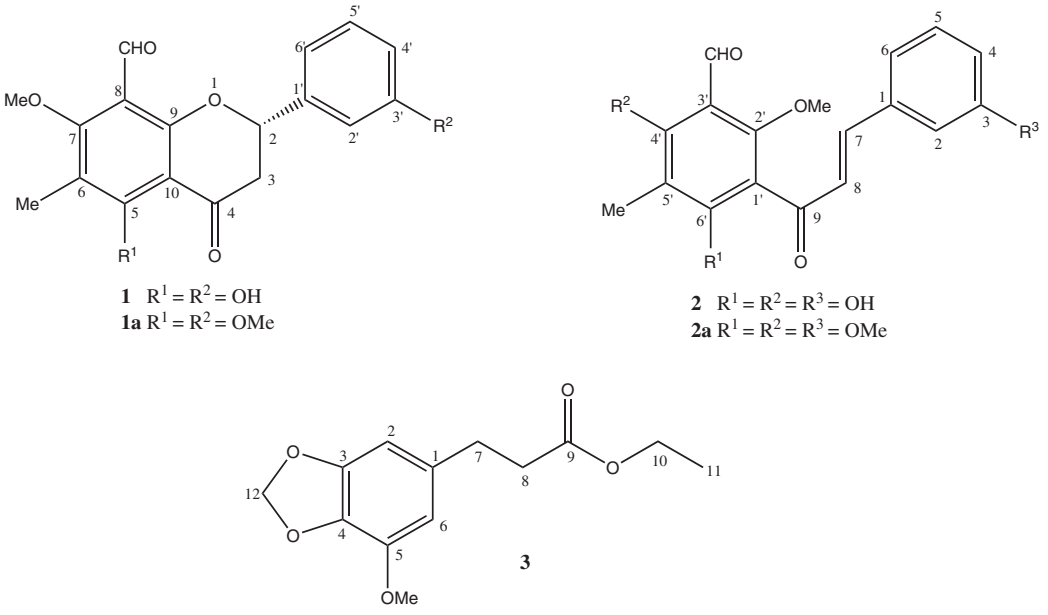

Figure 1. Structures of the isolated compounds **1-3** from *Piper montealegreanum*.

12.63 (s, 1H)] evidenced the chelated hydroxyl at C-5 with the C=O of the α,β-unsaturated carbonyl group.[13]

In the HMBC spectrum, the presence of cross peaks at δ_H 12.63 with δ_C 166.3 and 109.3, besides the cross peak at δ_H 2.05 with δ_C 166.3, 166.1 and 109.3, evidenced the existence of a methyl group at C-6 and also suggested the attachment position of the methoxyl group at C-7. This was confirmed by correlation of the peak at δ_H 10.15 (aldehyde hydrogen) and δ_H 3.99 (methoxyl hydrogen) with δ_C 166.1, and consequently, the placement of the formyl group at C-8 (Figure 2).

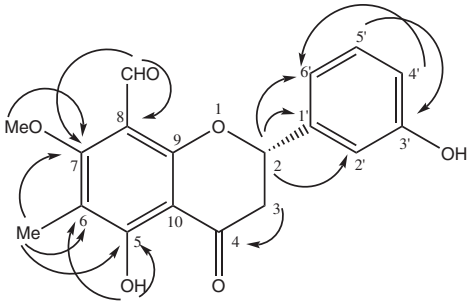

Figure 2. HMBC correlations of **1**.

The compound **1a** (Figure 1), a methylated derivative of **1,** showed correlations in HMQC spectrum between δ_H 3.95 / δ_C 64.3 and δ_H 3.82 / δ_C 55.3. The HMBC spectrum displayed correlations between δ_H 3.95 and 2.14 / δ_C 164.6 confirming the methoxyl group at C-5. The presence of cross peaks between signals in δ_H 3.82 / δ_C 159.9 supported the methoxyl group at the C-3'.

Compound **2** was obtained as yellow crystals. The MS spectrum gave a molecular ion peak at *m/z* 327.0870 $(M-1)^-$, in LC-MS-IT-TOF apparatus. The ^{1}H NMR spectrum indicated signals at δ_H 7.78 and 7.84 suggesting the presence of protons on a α,β-unsaturated ketone moiety.[13,16] The above data and UV absorption bands (λ_{max}) at 317 and 282 nm suggested a chalcone structure for compound **2**.[13] Signals for four coupled aromatic protons: a triplet at δ_H 7.33 (1H, J 7.8 Hz), a multiplet at δ_H 7.28-7.23 (m, 2H) and a double double doublet at δ_H 6.97 (1H, *J* 7.8, 2.0 and 1.6 Hz) suggested a 3'-substituted B ring.[15] Additionally, the ^{1}H NMR spectrum showed tree singlets at δ_H, 2.01 (3H), 4.01 (3H) and 10.17 (1H), consistent with the presence of methyl, methoxyl and aldehyde groups, respectively, besides two hydroxyl group singlets at δ_H 12.83 and 14.21. The two low-field hydroxyl protons evidenced a formyl group at C-3'. This conclusion is achieved since the down-field shift of OH-4' (δ_H 12.83) can be explained by hydrogen-bonding with the oxygen atom of the formyl substituent at a neighboring carbon atom and at the same time that the down-field shift of OH-6' (δ_H 14.21) is caused by chelation between the 6'-hydroxyl proton and the carbonyl oxygen of the α,β-unsaturated carbonyl group function.[13] This intramolecular hydrogen bonding corroborated the assignments of the signals at δ 7.78 (d, 1H) and δ 7.84 (d, 1H) to α and β positions, respectively.[16] Spectral analysis of **2a** showed H_α and H_β signals with a marked difference in chemical shifts [δ 7.29 (d, 1H, *J* 16.0 Hz, H-7) and δ 6.98 (d, 1H, *J* 16.0 Hz, H-8)] related with the absence of the intramolecular hydrogen bonding with the C=O of the α,β-unsaturated carbonyl group. The

coupling constant (16.0 Hz) observed in **2a** indicated the *E*-isomer for the double bond.[16] The placement of the other groups in the A-ring was made on the basis of the HMBC correlations (Figure 3): δ_H 14.21 (s, 1H, OH-6') / δ_C 169.8 and 109.0; δ_H 12.83 (s, 1H, OH-4') / δ_C 166.6, 109.2 and 109.5; δ_H 2.01 (s, 3H) / δ_C 109.2; δ_H 10.17 (s, 1H) / δ_C 166.6 and δ_C 109.5; δ_H 4.01 / δ_C 168.5 that evidenced the hydroxyl, formyl, methyl and methoxyl groups at C-6'-4', C-3', C-5' and C-2', respectively.

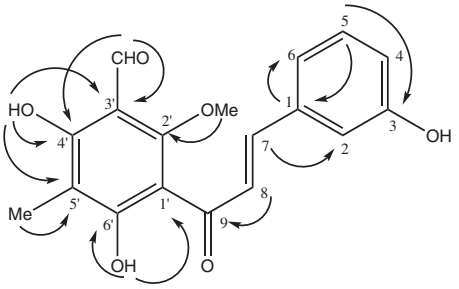

Figure 3. HMBC correlations of **2**.

The hydroxyl group in the C-3 was confirmed for the methylated derivative of **2** (Figure 1) which showed correlation between δ_H 3.80 / δ_C 55.3 in the HMQC spectrum and δ_H 3.80 / δ_C 159.9 (C-3) in the HMBC spectrum. Other correlations observed in the HMQC spectrum of **2a** were δ_H 3.86 / δ_C 62.7 and δ_H 3.75 / δ_C 61.9. In the HMBC spectrum, the signals at δ_H 3.86 and 3.75 showed correlations with δ_C 163.0 and 161.8, respectively, providing support for the presence of the methoxyl groups at the C-6' and C-4' position.

Formyl flavonoids have been reported from a few species in the plant kingdom. Early reports included a description of 2',4-dihydroxy-4'-methoxy-5'-formylchalcone from *Psoralea corylifolia* (Fabaceae).[17] Its isomeric compound, with methoxy group at the 2'-position, has been reported from the same species.[18] 2',4',6'- trihydroxy-3'-formylchalcone has been reported from *Psidium acutangulum* (Myrtaceae)[19] and its retrochalcone derivative was obtained from *Anredera scandens* (Basellaceae).[20] 3'-formyl-4',6'-dihydroxy-2'-methoxy-5'-methylchalcone and (2*S*)-8-formyl-5-hydroxy-7-methoxy-6-methylflavanone were isolated from *Cleistocalyx operculatus* (Myrtaceae).[13]

The compound **3** was obtained as yellow powder. The ^{1}H spectrum showed two doublets in δ_H 6.37 (*J* 1.4 Hz, 1H) and δ_H 6.34 (*J* 1.4 Hz, 1H) typical of *meta* aromatics hydrogens in addition to two singlets in δ_H 5.91 (2H) and 3.86 (3H) typical of methylenedioxy and methoxyl groups, respectively. These data suggested the presence of tetrasubstituted aromatic ring. The signals in δ_H 4.11 (q, 2H, *J* 7.0 Hz) and 1.23 (t, 3H, *J* 7.0 Hz) supported the presence of ethyl group attached to heteroatom and also two signals at δ_H 2.84 (t, 2H, *J* 7.5 Hz) and 2.55 (t, 2H, *J* 7.5 Hz) typical of methylene hydrogens.

The ^{13}C NMR spectrum of **3** showed 13 signals. The signals at δ_H 2.84, 2.55 and 4.11 are, in the HMBC spectrum, correlated with a signal characteristic of carbonyl ester at δ_C 172.8, confirming the assignment of the chemical shifts for H-7, H-8 and H-10, respectively, and δ_C 172.8 for C-9 of a dihydrocinnamoyl group. The HMBC spectrum also showed correlations between δ_H 3.86 / δ_C 148.8, δ_H 5.91 / δ_C 143.5 and 133.5, confirming the methoxyl and methylenedioxy groups at C-5 and C-3-4, respectively.

Experimental

General procedures

Melting points (mp) were determined on a MQAPF-302 melting point digital apparatus. UV spectra were recorded on a Vankel-50 UV-Vis spectrophotometer. IR spectra were obtained on an FT-IR-1750 spectrophotometer, Perkin-Elmer apparatus. The spectra mass were obtained on a SHIMADZU LCMS-IT-TOF (225-07100-34) equipped with a Z-spray ESI (electrospray) source and operated in negative mode.

^{1}H and ^{13}C NMR (1D and 2D) spectra were recorded on a Varian Mercury 200 spectrometer in $CDCl_3$ and $(CD_3)_2CO$, with TMS as internal standard. Sephadex LH-20 and silica gel 60 (PF_{254} art. 7749 and art. 7731) were purchased from Merck.

The methylated flavonoids were obtained by treatment of the sample, dissolved in dry propanone, with 1.1 equiv. of dimethyl sulphate (Me_2SO_4) and 1.1 equiv. of potassium carbonate (K_2CO_3) to each free hydroxyl. The reactions were carried at room temperature during 12 h. After removal of the solvent in vacuum, the residue was suspended in H_2O (50 mL), treated with 5 mL of ammonia and extracted with $CHCl_3$ (3 × 15 mL). The $CHCl_3$ solution was dried with Na_2SO_4, filtrated and concentrated to dryness.[13]

Plant material

Branches of *Piper montealegreanum* Yuncker was collected in Belém (Pará State, Brazil), in December 2002 and identified in the Botanical Garden, Rio de Janeiro (Rio de Janeiro State, Brazil). A voucher specimen (MSP-010) was deposited at Emilio Goeldi Museum, Belém.

Extraction and isolation

The powered material of *P. montealegreanum* (1.3 kg) was exhaustively extracted with EtOH (4 × 2.0 L), the solvent removed under reducted pressure furnished a green residue (115.0 g). The crude extract amount of 13.5 g was chromatographed over Sephadex gel LH-20 and eluted with methanol (column 1) yielding 43 fractions. Fraction 17 was further fractionated over Sephadex gel LH-20 column providing 5 fractions. Fraction 3 after submitted to recristalization with a chloroform and methanol mixture yielding (*S*)-8-formyl-3',5-dihydroxy-7-methoxy-6-methyl-flavanone (**1**) (30 mg).

Fraction 18 (column 1) was chromatographed over Sephadex LH-20 and yielded five fractions. Fraction 4 gave 3'-formyl-3,4',6'-trihydroxy-2'-methoxy-5'-methylchalcone (**2**) (40 mg), after submitted to recristalization with a chloroform and methanol mixture.

Fractions 8-11 (column 1) were also fractionated over Sephadex gel yielding 29 fractions. Fraction 8-14, after recrystallization with chloroform, gave ethyl 3,4-methylenedioxy-5-methoxy-7,8-dihydrocinnamate (**3**) (12 mg).

*Compound **1***. Orange yellow crystals ($CDCl_3$:MeOH); mp 162 °C; $[\alpha]_D^{25}$ −20 (MeOH, 0.025); UV λ_{max}/nm (MeOH): 266; UV λ_{max}/nm ($AlCl_3$): 286, 323 (sh); IR ν_{max}/cm^{-1} (KBr): 3425, 1688, 1620, 1570, 1464; MS $[M-1]^-$ 327.0887; ^1H and ^{13}C NMR spectral data, see Table 1.

*Compound **2***. Yellow crystals ($CHCl_3$:MeOH); mp 164 °C; UV λ_{max}/nm (MeOH): 317, 282; UV λ_{max}/nm ($AlCl_3$): 349, 306; IR (KBr) ν_{max}/cm^{-1}: 3445, 1616, 1581, 1422; MS $[M-1]^-$ 327.0870; ^1H and ^{13}C NMR spectral data, see Table 1.

*Compound **1a** and **2a***. ^1H and ^{13}C NMR spectral data, see Table 2.

*Compound **3***. Amorphous green powder; IR (KBr) ν_{max}/cm^{-1}: 2924, 2853, 1734; MS $[M^+]$ 252; ^1H and ^{13}C NMR spectral data, see Table 3.

Table 1. ^1H and ^{13}C NMR data for compounds **1** and **2**

Position	Chemical shift, δ (^1H)		Chemical shift, δ (^{13}C)	
	1	**2**	**1**	**2**
1	-	-	-	137.1
2	5.43 (dd, 1H, *J* 10.8 and 4.6 Hz)	7.28-7.23 (m, 1H)	78.3	115.5
3	2.97 ax, (dd, 1H, *J* 17.0 and 10.8 Hz)	-	45.0	158.9
	2.85 eq, (dd, 1H, *J* 4.6 and 17.0 Hz)			
4	-	6.97 (ddd, 1H, *J* 7.8. 2.0 and 1.6 Hz)	188.9	119.1
5	-	7.33 (t, 1H, *J* 7.8 Hz)	166.3	131.1
6	-	7.28-7.23 (m, 1H)	109.3	121.3
7	-	7.78 (d, 1H, *J* 15.5 Hz)	166.1	145.8
8	-	7.84 (d, 1H, *J* 15.5 Hz)	109.9	126.3
9		-	165.6	193.8
10	-	-	107.5	-
1'	-	-	139.7	109.0
2'	6.93 (m, 2H)	-	112.8	168.5
3'	-	-	156.3	109.5
4'	6.85 (dl, 1H, *J* 8.0 Hz)	-	115.8	166.6
5'	7.26 (t, 1H, *J* 8.0 Hz)	-	130.2	109.2
6'	6.93 (m, 2H)	-	117.8	169.8
OMe	3.99 (s, 3H)	4.01 (s, 3H)	64.6	67.0
Me	2.05 (s, 3H)	2.01 (s, 3H)	7.2	6.7
CHO	10.15 (s, 1H)	10.17 (s, 1H)	193.8	194.3
OH-5	12.63 (s, 1H)	-	-	-
OH-4'	-	12.83 (s, 1H)	-	-
OH-6'	-	14.21 (s, 1H)	-	-

Table 2. ^{1}H and ^{13}C NMR data for methylated compounds **1a** and **2a**

Position	Chemical shift, δ (^{1}H)		Chemical shift, δ (^{13}C)	
	1a	**2a**	**1a**	**2a**
1	-	-	-	135.5
2	5.48 (dd, 1H, *J* 12.0 and 4.0 Hz)	7.02 (m, 1H)	78.9	113.2
3	3.02 ax (dd, 1H, *J* 16.7 and 12.0 Hz); 2.87 eq (dd,1H, *J* 16.7 and 4.0 Hz)	-	45.3	159.9
4	-	6.91 (m, 1H)	188.8	116.9
5	-	7.27 (t, 1H, *J* 7.8 Hz)	164.6	129.9
6	-	7.12 (m, 1H)	117.3	121.4
7	-	7.29 (d, 1H, *J* 16.0 Hz)	164.8	146.4
8	-	6.98 (d, 1H, *J* 16.0 Hz)	117.9	128.3
9	-	-	165.6	193.7
10	-	-	115.6	-
1’	-	-	139.6	122.1
2’	7.03-6.99 (m, 2H)	-	111.8	158.9
3’	-	-	159.9	119.23
4’	6.94-6.88 (m, 1H)	-	113.9	161.8
5’	7.35 (t, 1H, *J* 8.2 Hz)	-	130.0	125.1
6’	7.03-6.99 (m, 2H)	-	118.0	163.0
OMe-3’	3.82 (s, 3H)	-	55.3	-
OMe-5	3.95 (s, 3H)	-	64.3	-
OMe-7	3.83 (s, 3H)	-	62.3	-
Me	2.14 (s, 3H)	2.19 (s, 3H)	8.4	8.9
CHO	10.33 (s, 1H)	10.30 (s, 1H)	188.2	188.2
OMe-2’	-	3.78 (s, 3H)	-	64.5
OMe-4’	-	3.75 (s, 3H)	-	61.9
OMe-6’	-	3.86 (s, 3H)	-	62.7
OMe-3	-	3.80 (s, 3H)	-	55.3

Table 3. ^{1}H (200 MHz) and ^{13}C (50 MHz) NMR data for compound **3** and correlations obtained in HMQC and HMBC experiments, *J* (Hz) in parenthesis

Positions	HMQC			HMBC
	δ_H	$\delta_C \times \delta_H$ (^{1}J)	$\delta_C \times \delta_H$ (^{2}J)	$\delta_C \times \delta_H$ (^{3}J)
1	-	135.2		
2	6.37 (d, 1H, *J* 1.4 Hz)	102.3	148.8	107.5
3	-	148.8		
4	-	133.5		
5	-	143.5		
6	6.34 (d, 1H, *J* 1.4 Hz)	107.5	143.5	133.5; 102.3; 31.1
7	2.84 (t, 2H, *J* 7.5 Hz)	31.1	135.2; 36.3	172.8; 107.5; 102.3
8	2.55 (t, 2H, *J* 7.5 Hz)	36.3	172.8; 31.1	135.2
9	-	172.8		
10	4.11 (q, *J* 7.0 Hz)	60.5	14.2	172.2
11	1.23 (t, 3H, *J* 7.0 Hz)	14.2		
12	5.91 (s, 2H)	101.2		148.8; 133.5
OMe-5	3.86 (s, 3H)	56.5		143.5

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Supplementary Information

Supplementary information (^{1}H and ^{13}C NMR data for compounds **1**, **2**, **3**, **1a** and **2a**, Figures S1-S15) is available free of charge at http://jbcs.org.br as a PDF file.

References

1. Yuncker, T. G.; *Hoehnea* **1972**, *2*, 36.
2. Araújo-Jr, J. X.; Chaves, M. C. O.; Da Cunha, E. V. L.; Gray, A. I.; *Phytochemistry* **1997**, *44*, 559.
3. Chaves, M. C. O.; Santos, B. V. O.; *Biochem. Syst. Ecol*. **1998**, *27*, 113.
4. Chaves, M. C. O.; Da Cunha, E. V. L.; *Fitoterapia* **2001**, *72*, 197.
5. Chaves, M. C. O.; Figueiredo-Jr, A. G.; Santos, B. V. O.; *Fitoterapia* **2003**, *74*, 181.
6. Araújo-Jr, J. X.; Chaves, M. C. O.; Da Cunha, E. V. L.; Gray, A. I.; *Biochem. Syst. Ecol*. **1999**, *27*, 325.
7. Cardozo-Júnior, E. L.; Chaves, M. C. O.; *Pharm. Biol.* **2003**, *41*, 216.
8. Oliveira, L. C. P.; Mause, R.; Nunomura, S. M.; *J. Braz. Chem. Soc.* **2005**, *16*, 1439.
9. Chaves, M. C. O.; Santos, B. V. O.; *Biochem. Syst. Ecol*. **1999**, *27*, 539.
10. Chaves, M. C. O.; Santos, B. V. O.; *Fitoterapia* **2002**, *73*, 547.
11. Santos, B. V. O.; Chaves, M. C. O.; da Cunha, E. V. L.; Gray, A.I.; *Biochem. Syst. Ecol*. **1997**, *25*, 471.
12. Santos, B. V. O.; Chaves, M. C. O.; da Cunha, E. V. L.; Gray, A. I.; *Phytochemistry* **1998**, *49*, 1381.
13. Ye, Chun L.; Yan-Hua, L.; Dong-Zhi, W.; *Phytochemistry* **2004**, *65*, 445.
14. Asai, T.; Hara, N.; Kobayashi, S.; Fujimoto, Y.; *Phytochemistry* **2008,** *69,* 1234.
15. Alavez-Solano, D.; Reyes-Chilpa, R.; Jiménez-Estrada, M.; Gómez-Garibay, F.; Chavez-Uribe, I.; Sousa-Sánchez, M.; *Phytochemistry* **2000,** *55*, 953.
16. Quintin, J.; Desrivot, J.; Thoret, S.; Le Menez, P.; Cresteil, T.; Lewin, G.; *Bioorg. Med. Chem. Lett*. **2009**, *19,* 167.
17. Gupta, S. R.; Seshadri, T. R.; Good, G. R.; *Indian J. Chem*. **1975,** *13B*, 632.
18. Gupta, B. K.; Gupta, G. K.; Dhar, K. L.; Atal, C. K.; *Phytochemistry* **1980**, *19*, 2034.
19. Miles, D. H.; de Medeiros, J. M. R.; Chittawong, V.; Hedin, P. A.; Swithenbank, C.; Lidert, Z.; *Phytochemistry* **1991**, *30*, 1131.
20. Calzada, F.; Mata, R.; Bye, R.; Linares, E.; *Phytochemistry* **1990**, *29*, 2737.
21. Silva, T. M. S.; Carvalho, M. G.; Braz-Filho, R.; *Quim. Nova* **2009**, *32*, 1119.

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Supplementary Information

Three New Compounds from *Piper montealegreanum* Yuncker (Piperaceae)

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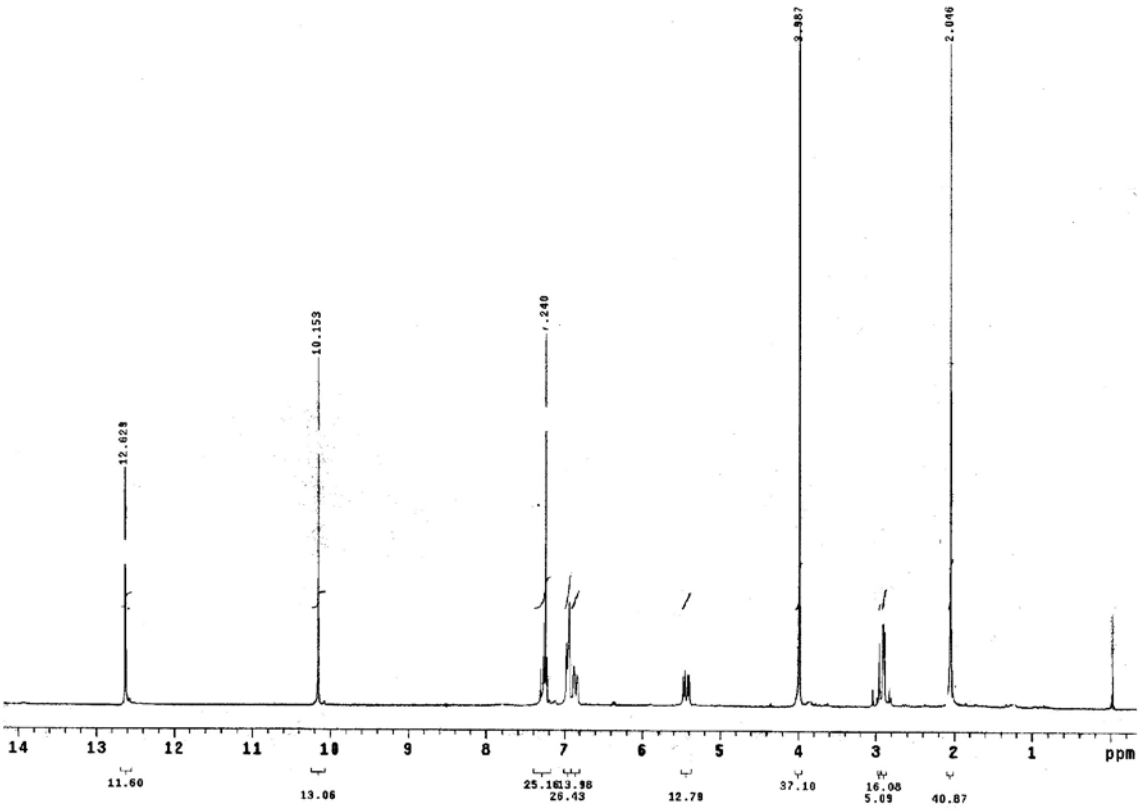

Figure S1. ^{1}H NMR spectrum (δ, $CDCl_3$, 200 MHz) of **1**.

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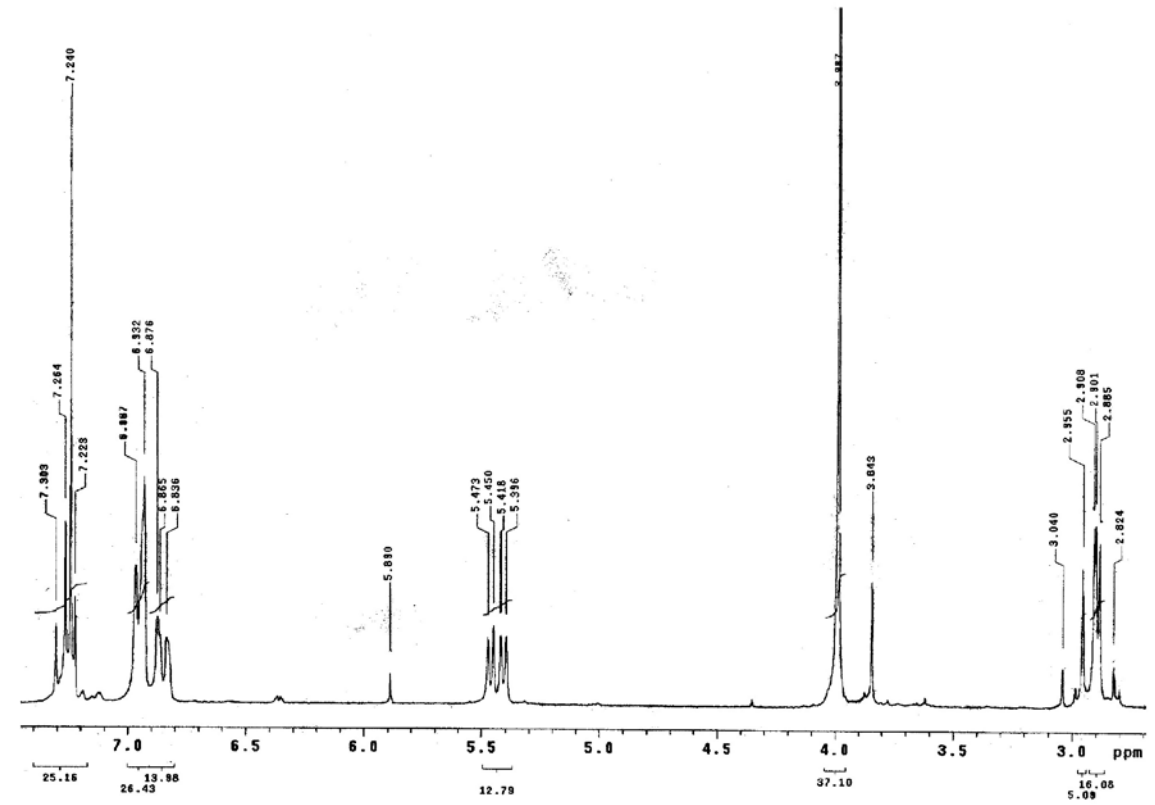

Figure S2. ^{1}H NMR spectrum (δ 8.0-2.8 ppm, $CDCl_3$, 200 MHz) of **1**.

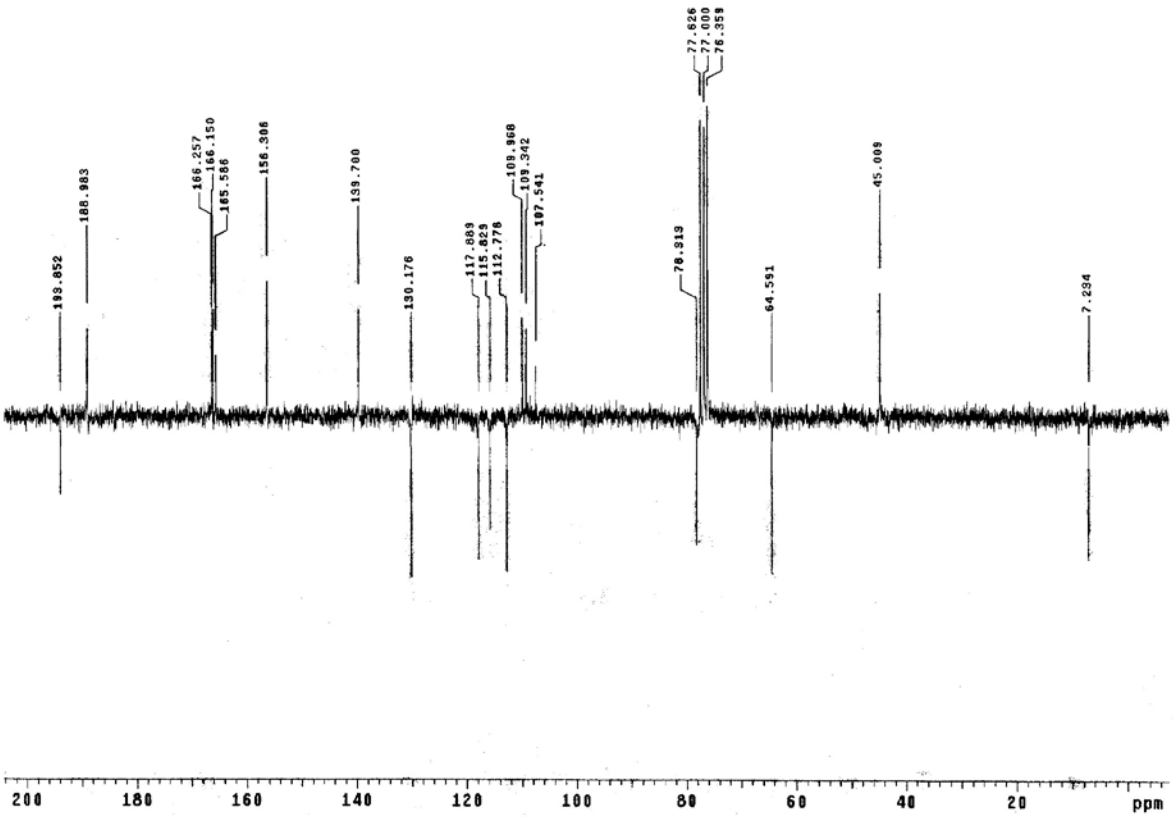

Figure S3. ^{13}C NMR (APT) spectrum (δ, $CDCl_3$ 50MHz) of **1**.

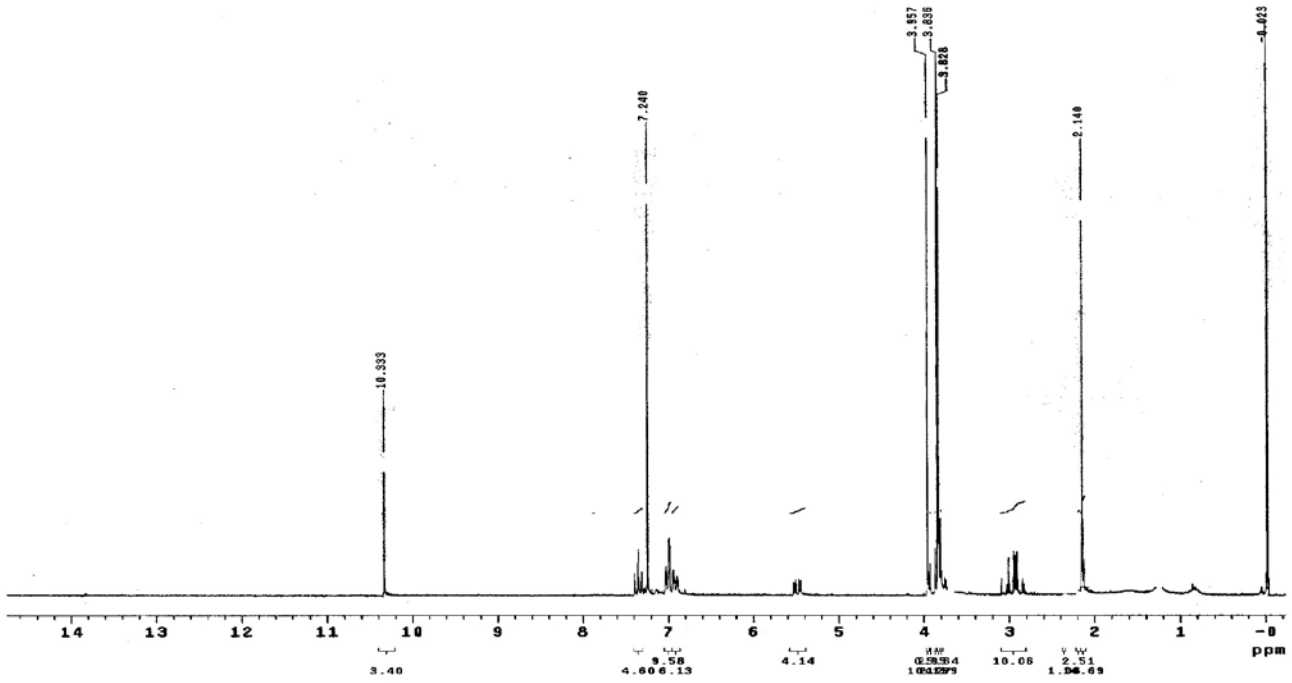

Figure S4. [1]H NMR spectrum (δ, $CDCl_3$, 200 MHz) of **1a**.

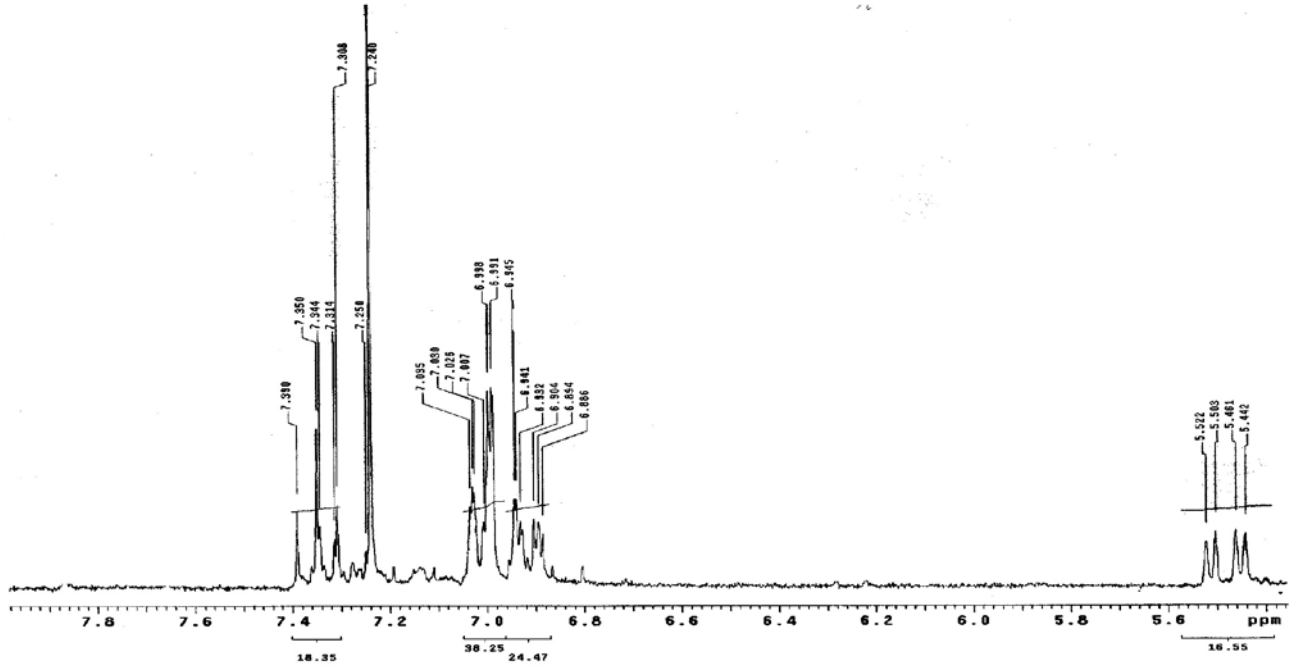

Figure S5. [1]H NMR spectrum (δ 7.8-5.4 ppm, $CDCl_3$, 200 MHz) of **1a**.

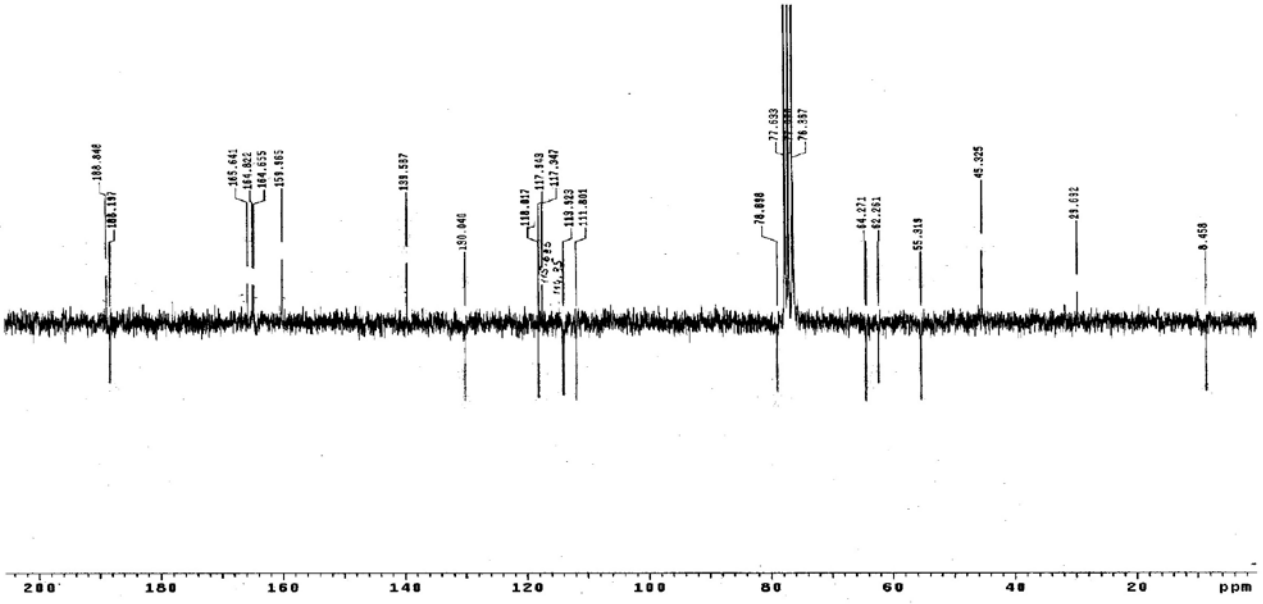

Figure S6. ^{13}C NMR (APT) spectrum (δ, $CDCl_3$ 50MHz) of **1a**.

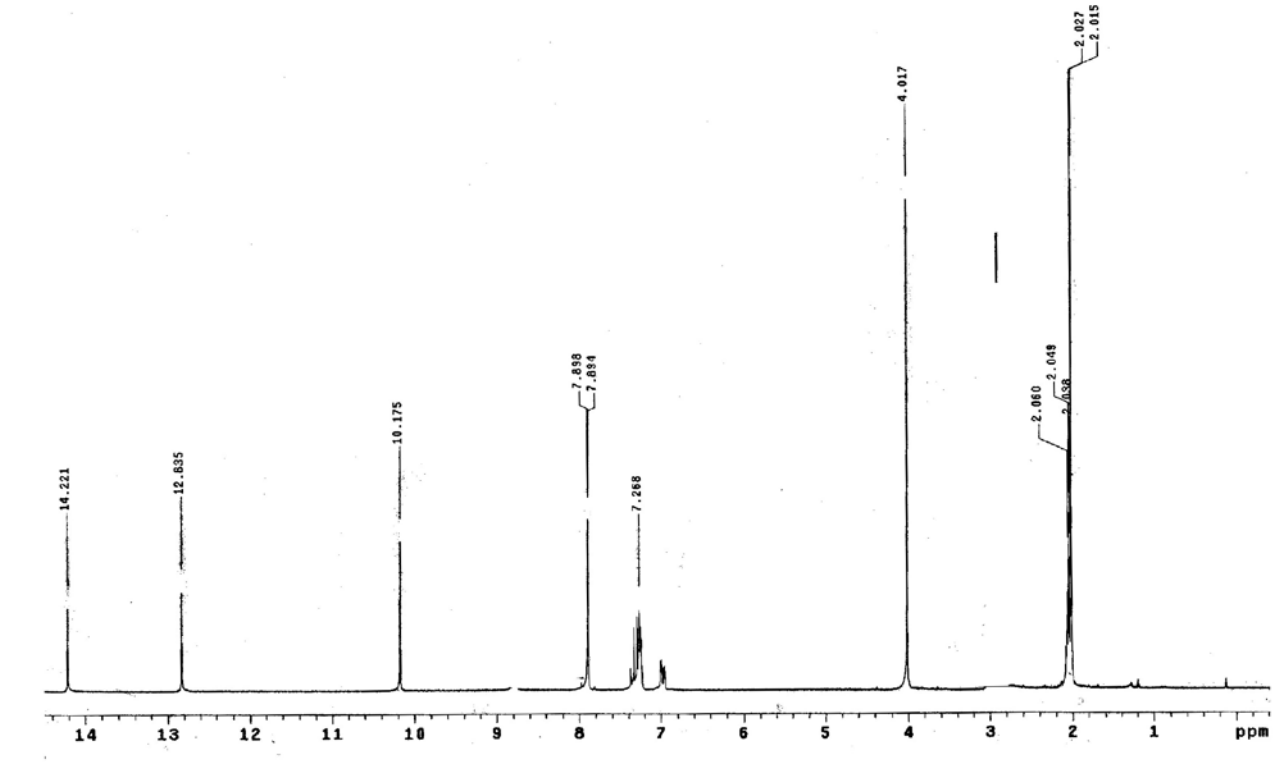

Figure S7. ^1H NMR spectrum (δ, $(CD_3)_2CO$, 200 MHz) of **2**.

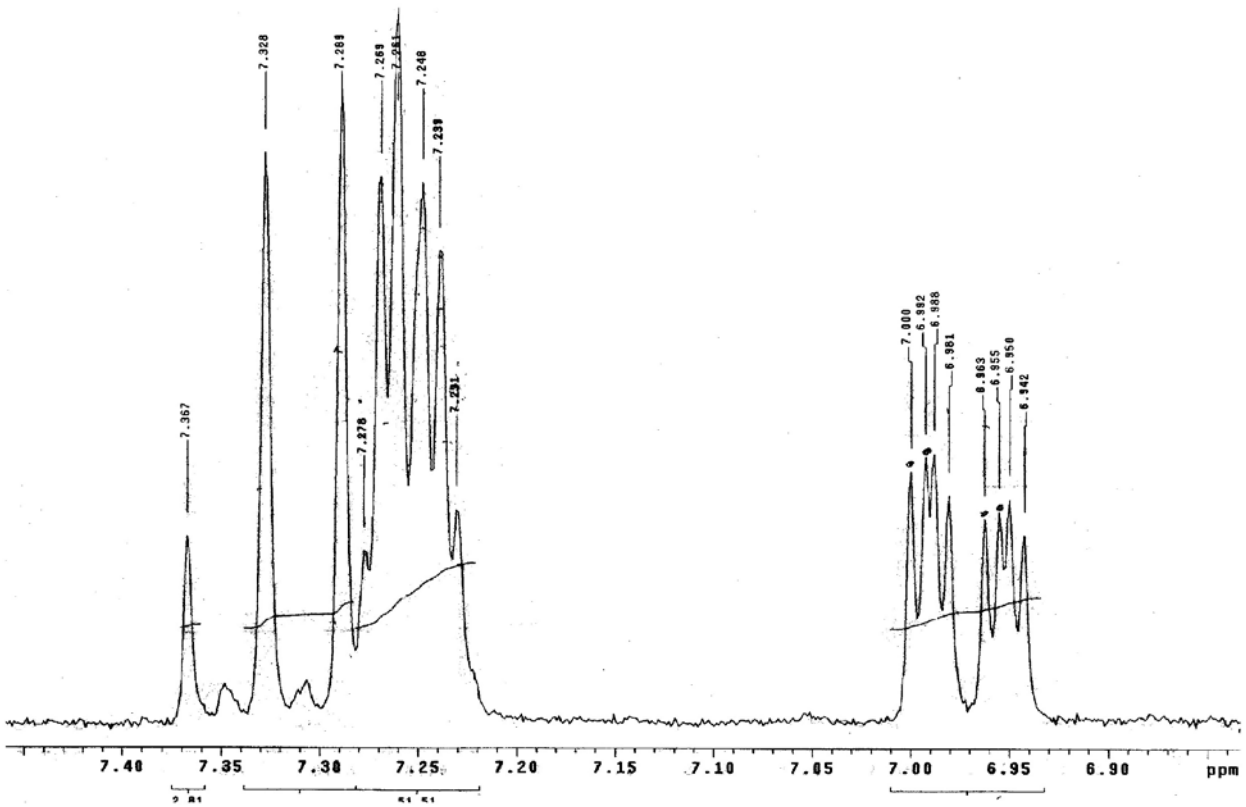

Figure S8. [1]H NMR spectrum (δ 7.4-6.8 ppm, $(CD_3)_2CO$, 200 MHz) of **2**.

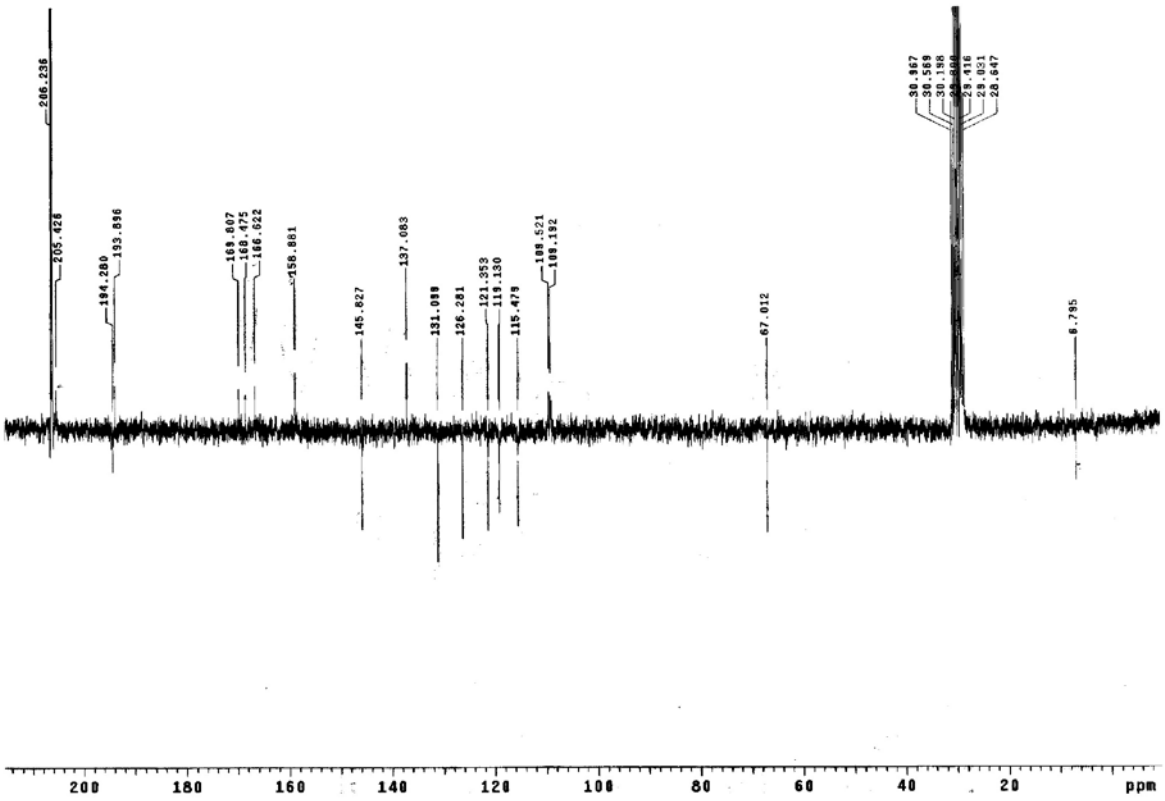

Figure S9. [13]C NMR (APT) spectrum (δ, $(CD_3)_2CO$, 50 MHz) of **2**.

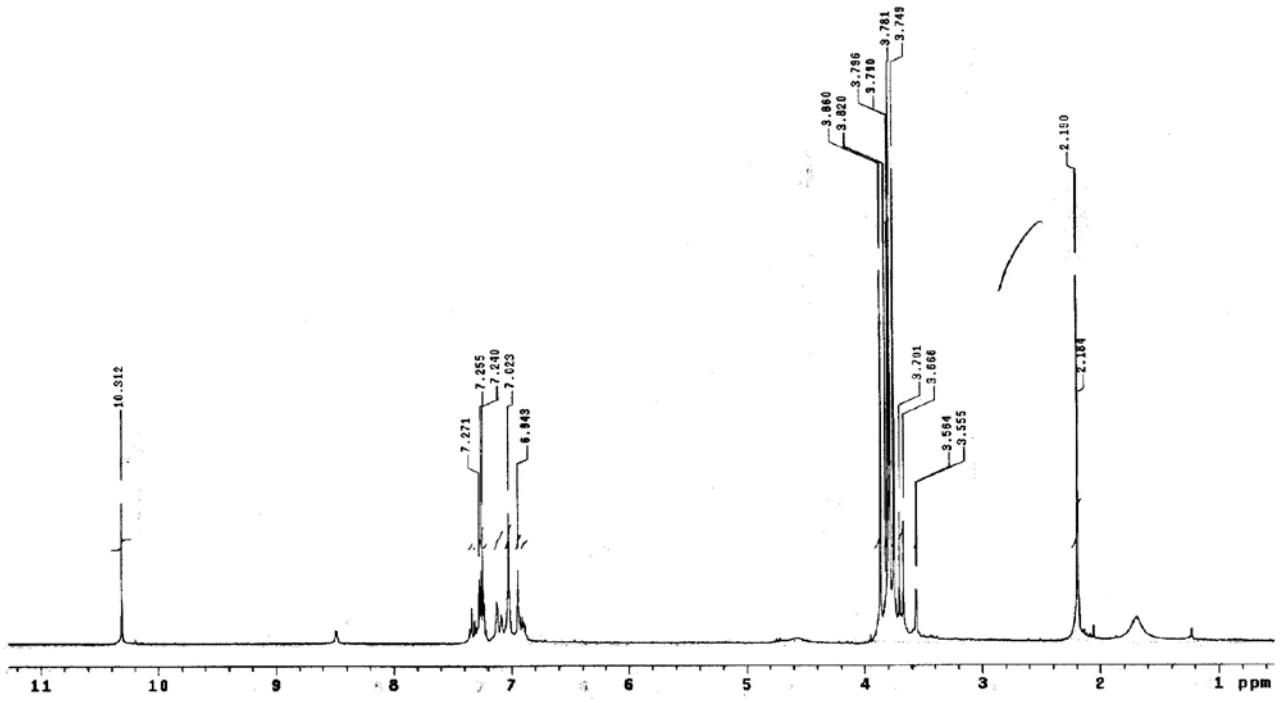

Figure S10. ^{1}H NMR spectrum (δ, $CDCl_3$, 200 MHz) of **2a**.

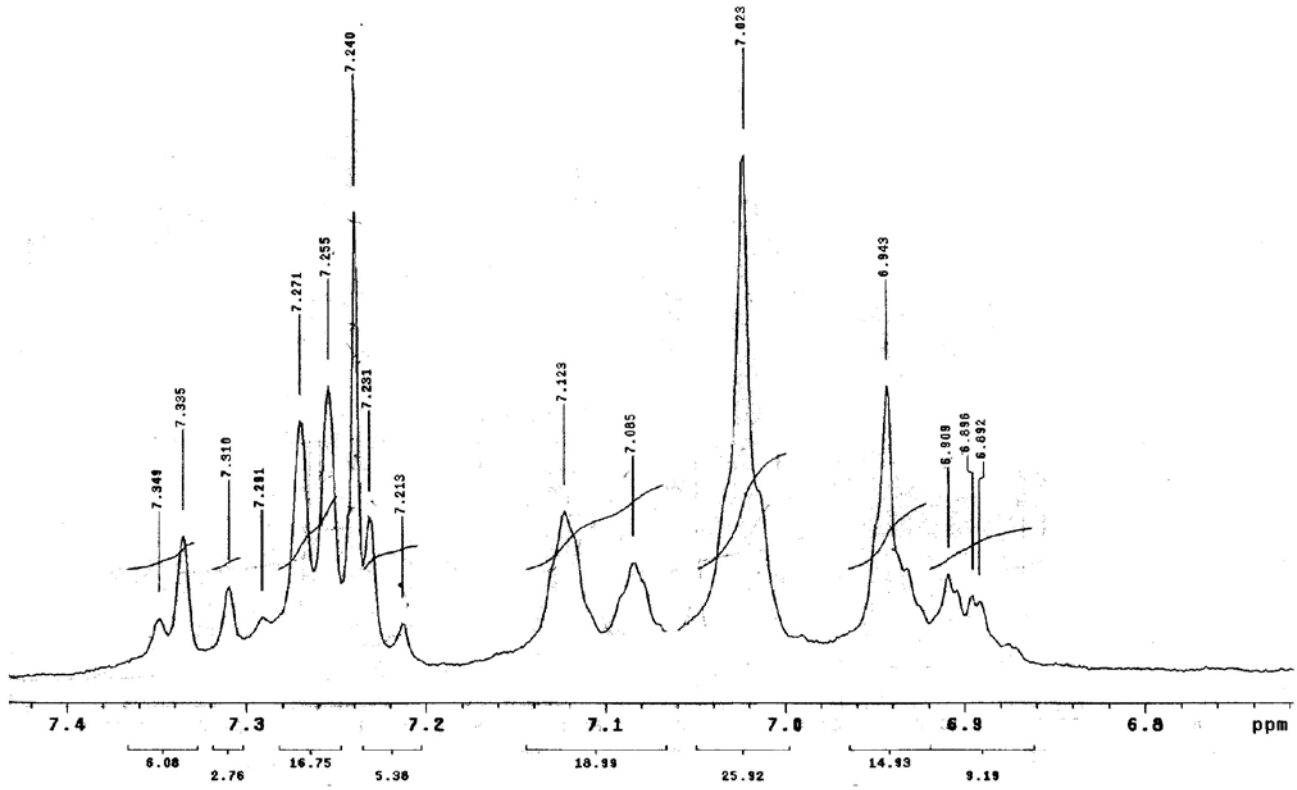

Figure S11. ^{1}H NMR spectrum (δ 7.4-6.8 ppm, $CDCl_3$, 200 MHz) of **2a**.

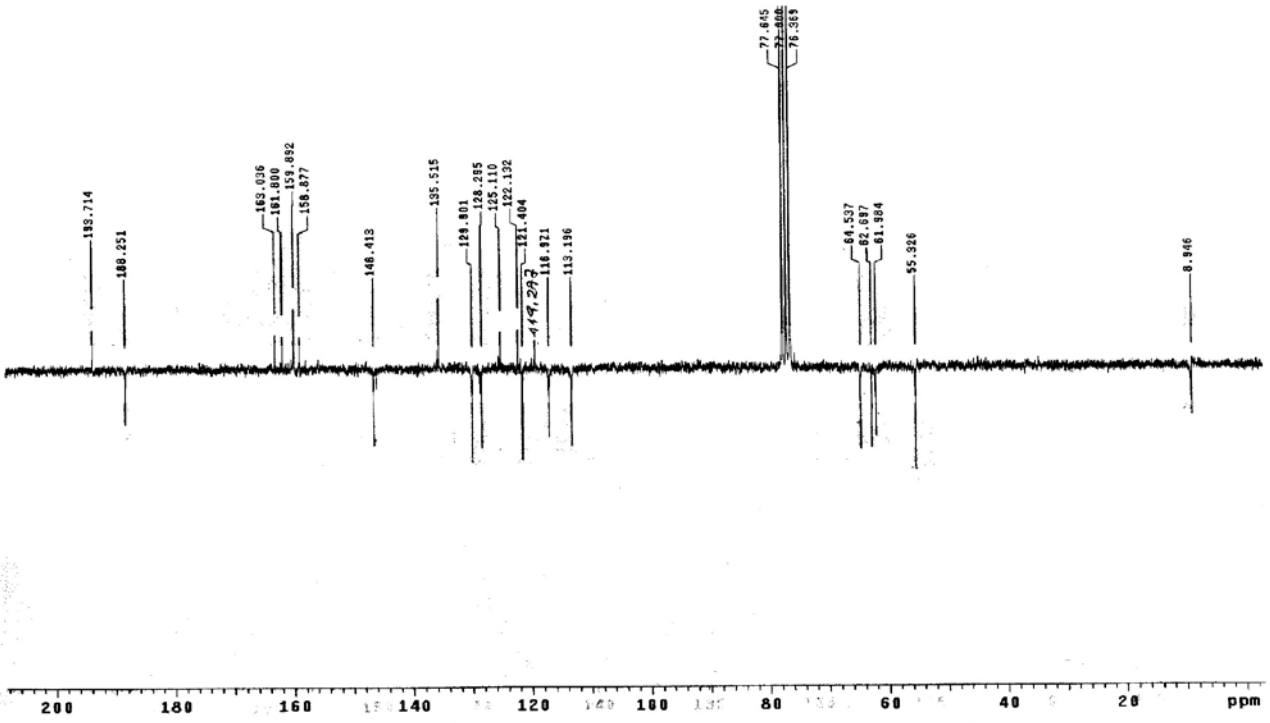

Figure S12. ^{13}C NMR (APT) spectrum (δ, $CDCl_3$ 50MHz) of **2a**.

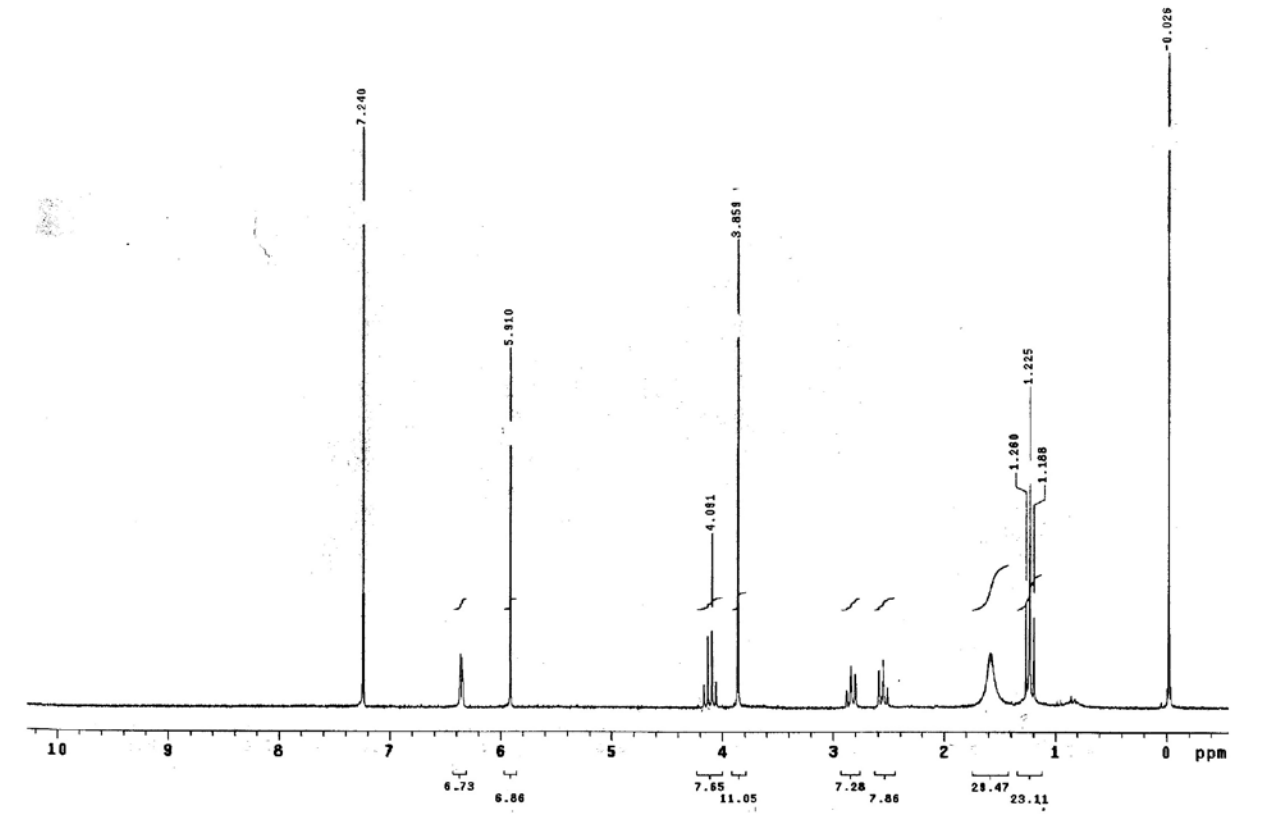

Figure S13. ^{1}H NMR spectrum (δ, $CDCl_3$, 200 MHz) of **3**.

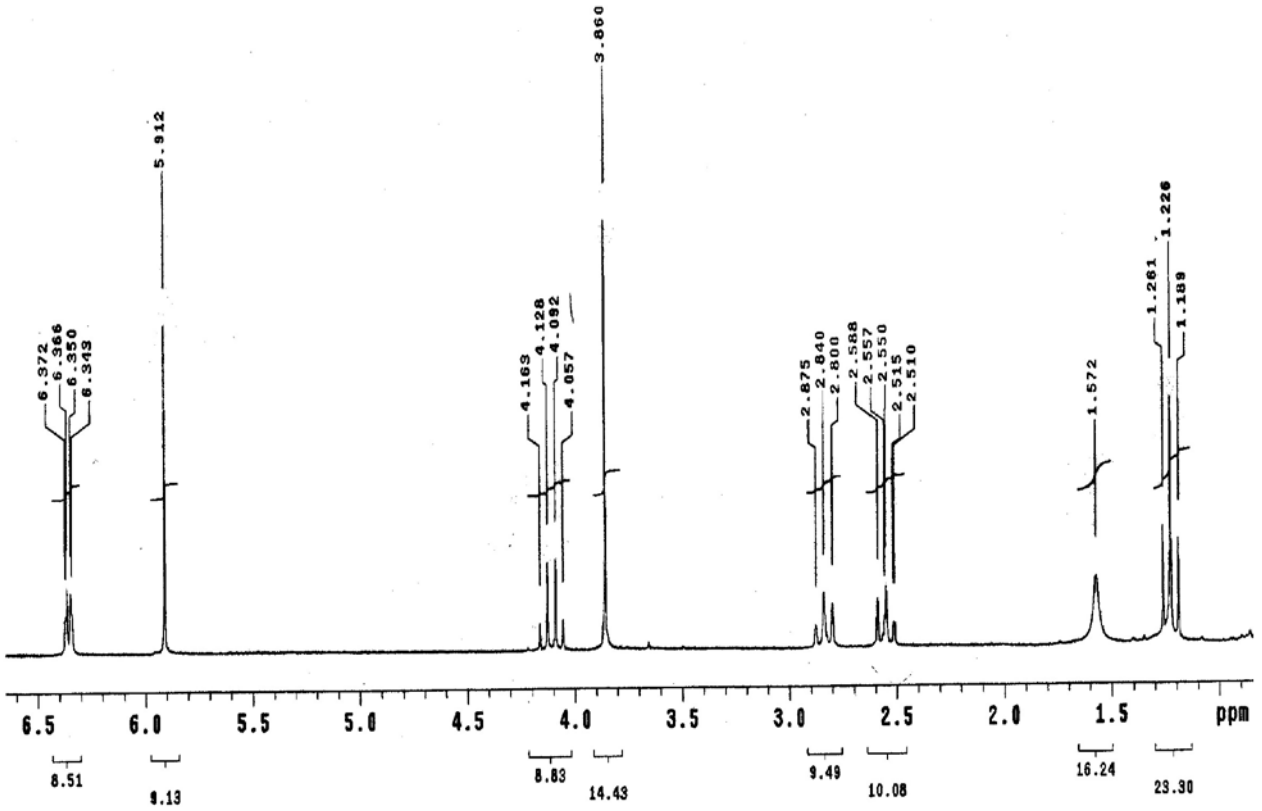

Figure S14. ^{1}H NMR spectrum (δ 6.5-1.0 ppm, $CDCl_3$, 200 MHz) of **3**.

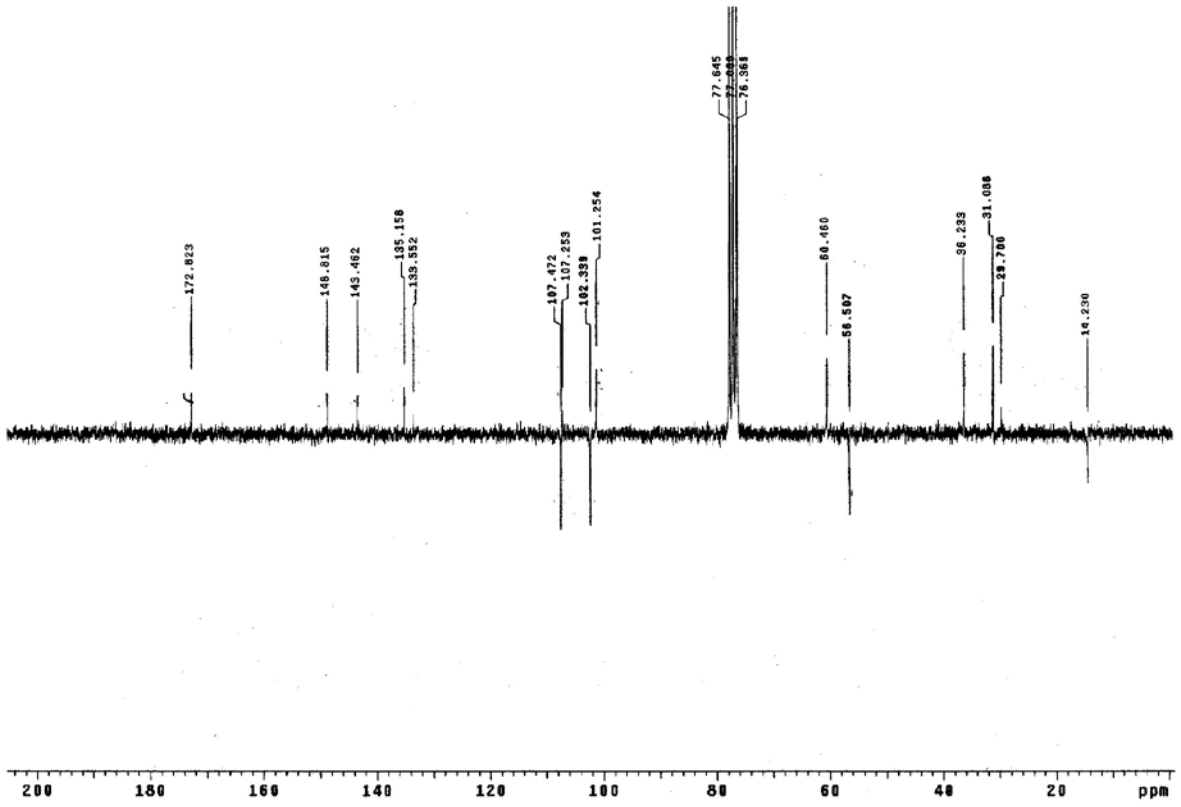

Figure S15. ^{13}C NMR (APT) spectrum (δ, $CDCl_3$, 50 MHz) of **3**.