Asian Journal of Chemistry; Vol. 26, No. 7 (2014), 1988-1990

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2014.15611

Synthesis, Crystal Structure and Insecticidal Activity of 1-[2-(3-Ethyl-2,2-dimethylcyclobutyl)acetyl]-3-*o*-tolylthiourea

YAN-BAI YIN[1,*], JIA HAN[2], YA-LI ZHANG[1], ZHAN-QIAN SONG[3] and TAO LIU[1]

[1]Jining Institute of Supervision & Inspection on Product Quality, Jining 272000, P.R. China
[2]Guohong Chemical Co., Ltd., Yankuang Group, Jining 273512, P.R. China
[3]Institute of Chemical Industry of Forest Products, Chinese Academy of Forestry, Nanjing 210042, P.R. China

*Corresponding author: E-mail: fenghzongyuzhe@163.com

Received: 9 April 2013; *Accepted*: 21 June 2013; *Published online*: 22 March 2014; AJC-14943

The compound 1-[2-(3-ethyl-2, 2-dimethylcyclobutyl)acetyl]-3-*o*-tolylthiourea has been synthesized and its structure was characterized by IR, ^{1}H NMR and single crystal X-ray diffraction. The crystal belongs to monoclinic system, space group $P2_1/c$, a = 14.335(3) Å, b = 9.7100(19) Å, c = 26.737(5) Å, α = 90°, β = 92.70(3)°, γ = 90°, V = 3717.5(13) Å^3, Z = 4, μ = 0.178 mm^{-1}, D_c = 1.138 g/cm^3, F(000) = 1376, R = 0.0921, wR2 = 0.1379, formula unit $C_{18}H_{26}N_2OS$. Present compound has a fragment of 2,2-dimethylcyclobutane and its conformation represents semi-chair. The intermolecular and intramolecular hydrogen bonds are revealed. Its insecticidal activity against *Ostrinia furnacalis* was also reported in this work.

Keywords: Synthesis, Single crystal X-ray diffraction, Crystal structure, Insecticidal activity.

INTRODUCTION

Many thiourea compounds exhibit strong structure stabilization and interesting biological activities. In recent years the synthesis and their biological activities have been studied. Many cyclobutyl analogues also have favourable bioactivities[1,2]. So the thiourea compounds containing cyclobutane ring may have interesting biological activities. In the study the application of cyclobutane ring is arranged into the structure of thiourea compounds to improve their properties and biological activities. In this paper, we reported the synthesis of 1-[2-(3-ethyl-2,2-dimethylcyclobutyl)acetyl]-3-*o*-tolylthiourea and its insecticidal activities against *Ostrinia furnacalis*.

EXPERIMENTAL

Preparation of the title compound: The synthesis of the compound has been performed according to the scheme shown in Fig. 1. 2,2-Dimethyl-3-ethylcyclobutaneacetic acid was prepared in our laboratory according to literature[3]. The title compound was synthesized according to following method.

2,2-Dimethyl-3-ethylcyclobutaneacetic acid (5 g, 0.029 mol) was dissolved in the mixture of dichloromethane (40 mL) and $SOCl_2$ (4.5 mL, 0.062 mol). The mixture was stirred and refluxed for 4 h. Then the excessive solution was removed by decompression distillation. The residue was added dropwise to the mixture of KSCN (3.0 g, 0.030 mol) and acetonitrile (30 mL). The resulting mixture was stirred for 4 h at room temperature. *o*-Toluidine (3.10 g, 0.029 mol) was added into the mixture. The reaction mixture was refluxed for 7 h. Then the excessive solution was removed by decompression distillation and the residue was poured into water (70 mL). Finally pumping filtration left the crude product as yellow powder. The solid was purified by recrystallization with ethanol in 85.6 % yield. m.p.: 87.2-88.4 °C. IR (KBr, ν_{max}, cm^{-1}): (N-H) 3169, (C=H) 3025, (C=O) 1686, (C-N) 1254, (C=S) 1151. ^{1}H NMR (400 MHz, $CDCl_3$, δ): 11.99 (s, 1H, NH), 8.63 (s, 1H, NH), 7.69 (d, 2H, C_6H_4-), 7.24(m, 2H, C_6H_4-), 2.50, 2.23 (m, 2H, CH_2), 2.39, 2.19 (m, 2H, CH_2), 2.30 (s, 3H, CH_3), 1.79 (m, 2H, CH_2) , 1.36 (s, 1H, CH), 1.23 (s, 1H, CH), 1.10-0.92 (q, 6H, CH_3) , 0.81 (m, 3H, CH_3).

Structure determination: A yellow single crystal of the title compound with dimensions of 0.30 mm × 0.20 mm × 0.10 mm was mounted on a ENRAF-NONIONS CAD4 equipped with a graphite-monochromatic MoK$_\alpha$ radiation (λ = 0.71073 Å) for data collection at 293(2) K. A total of 7036 reflections including 6631 independent ones (R_{int} = 0.0995) were obtained in the range of $1.42 < \theta < 25.33$, of which 2622 with $I > 2\sigma(I)$ were considered as observed and used in the succeeding refinements. The final R = 0.0921 and wR = 0.1379 ($w = 1/[\sigma^2(F_o^2) + (0.0500P)^2 + 0.0000P]$, where $P = (F_o^2 + 2Fc^2)/3$), S = 1.009 and $(\Delta/\sigma)_{max}$ = 0.000. The maximum and minimum peaks in the final difference Fourier map are 0.344 and -0.225 e/Å^3, respectively.

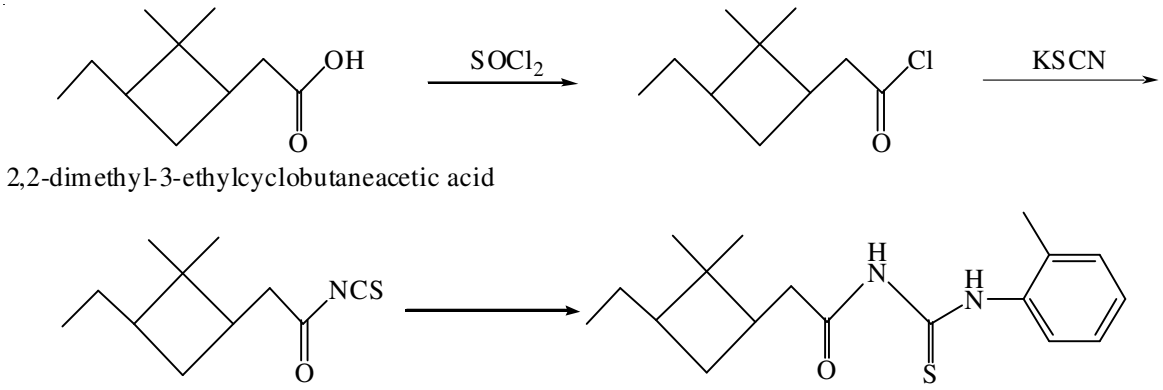

Fig. 1. Synthesis scheme of the title compound

RESULTS AND DISCUSSION

The IR and ^{1}H NMR for the product are in good agreement with the title compound. In order to determine the structure and configuration of the title compound X-ray diffraction study has been carried out. CCDC 892667 contains the supplementary crystallographic data for the title compound. The selected bond lengths and bond angles are listed in Tables 1 and 2.

Fig. 2 illustrates the structure of the title compound. As a whole, the molecule is substantially non-planar. The 2,2-dimethylcyclobutane fragment is not flat and the conformation represents semi-chair. The cyclobutane ring is flexed as though folded from the dimethyl substituted C (6) atom to the unsubstituted C (4) atom, with a dihedral angle of 29.0°. This is a little different from other compounds containing cyclobutane rings. In (±)-2-[(1*S*,3*S*)-3-acetyl-2,2-dimethylcyclobutyl]-N-(*p*-tolyl)acetamide the dihedral angle[4] is 23.7°; In (±)-*cis*-pinonic acid[5] and *(1S,3S)*-(+)-*cis*-3-acetyl-2,2-dimethylcyclobutaneacetic acid[6] the dihedral angle is 29.8°; in (+)-*trans*-pinonic acid[7] the angle is 19.1°; in methyl (±)-2-((1*R*,3*R*)-3-{2-[(3*S*)-1-ethyl-3-hydroxy-2-oxo-2,3-dihydro-1*H*-3-indolyl]acetyl}-2,2-dimethylcyclobutyl)acetate[8] the angle is 18.6°; in (-)-*cis*-3-acetyl-2,2-dimethylcyclobutanecarboxylic acid[9] the angle is 25.5°.

In the crystal structure, N (1), N(2) and the double bonds of C(10)=O(1), C(11)=S(1) are in the same plane. The atoms containing in the benzene ring, the C(18) atom attached to the benzene ring and N(2) are in the same plane. The dihedral angel between the two plances is 50.8°. The values of torsion angles C(1)-C(2)-C(3)-C(4), C(1)-C(2)-C(3)-C(6), C(4)-C(5)-C(9)-C(10), C(6)-C(5)-C(9)-C(10), H(5A)-C(5)-C(6)-C(7), H(5A)-C(5)-C(6)-C(8), H(5A)-C(5)-C(9)-H(9A), H(5A)-C(5)-C(9)-H(9B), H(5A)-C(5)-C(9)-C(10), C(4)-C(5)-C(9)-H(9A) and C(4)-C(5)-C(9)-H(9B) are equal to -49.0°, 168.3°, 160.2°, 57.9°, 47.2°, 165.3°, 16.3°, 43.6°, -77.6°, 39.0 ° and -78.7°, respectively.

There are two intramolecular hydrogen bonds and three intermolecular hydrogen bonds in the title compound which contributes to the stabilization of the crystal structure. The hydrogen bonds are shown in the Fig. 3 and Table-3.

In the crystal struture the C-N bond lengths are greatly varied. The bond lengths of N(1)-C(10), N(1)-C(11), N(2)-C(11) and N(2)-C(12) are equal to 1.377(8) Å, 1.399(8) Å,

TABLE-1
SELECTED BOND LENGTHS (Å)

Bond	Dist.	Bond	Dist.	Bond	Dist.	Bond	Dist.
S(1)-C(11)	1.642(7)	O(1)-C(10)	1.222(8)	C(4)-C(5)	1.634(10)	C(4)-H(4A)	0.9700
N(1)-C(10)	1.377(8)	N(1)-C(11)	1.399(8)	C(4)-H(4B)	0.9700	C(5)-C(6)	1.469(10)
N(1)-H(1A)	0.8600	N(2)-C(11)	1.312(8)	C(5)-C(9)	1.502(10)	C(5)-H(5A)	0.9800
N(2)-C(12)	1.430(8)	N(2)-H(2A)	0.8600	C(6)-C(7)	1.466(7)	C(6)-C(8)	1.533(11)
C(1)-C(2)	1.473(8)	C(1)-H(1B)	0.9600	C(7)-H(7A)	0.9600	C(7)-H(7B)	0.9600
C(14)-H(14A)	0.9300	C(15)-C(16)	1.350(11)	C(16)-H(16A)	0.9300	C(17)-H(17A)	0.9300
C(15)-H(15A)	0.9300	C(16)-C(17)	1.392(10)	C(18)-H(18B)	0.9600	C(18)-H(18A)	0.9600

TABLE-2
SELECTED BOND ANGLES (°)

Angles	(°)	Angles	(°)	Angles	(°)
C(1)-C(2)-H(2B)	108.1	C(3)-C(2)-H(2B)	108.1	H(1B)-C(1)-H(1C)	109.5
C(2)-C(1)-H(1B)	109.5	C(2)-C(1)-H(1D)	109.5	H(1B)-C(1)-H(1D)	109.5
H(1C)-C(1)-H(1D)	109.5	C(3)-C(2)-H(2C)	108.1	C(10)-N(1)-C(11)	129.5(6)
C(11)-N(2)-C(12)	128.1(6)	C(2)-C(1)-H(1C)	109.5	C(10)-N(1)-H(1A)	115.2
C(3)-C(4)-H(4B)	114.9	C(5)-C(4)-H(4B)	114.9	H(4A)-C(4)-H(4B)	112.0
C(6)-C(5)-C(9)	125.1(8)	C(6)-C(5)-C(4)	87.8(6)	C(9)-C(5)-C(4)	110.6(7)
C(6)-C(5)-H(5A)	110.3	C(9)-C(5)-H(5A)	110.3	C(4)-C(5)-H(5A)	110.3
C(3)-C(6)-C(7)	123.3(8)	C(3)-C(6)-C(5)	91.7(6)	C(7)-C(6)-C(5)	129.5(8)
C(17)-C(12)-C(13)	122.1(8)	C(17)-C(12)-N(2)	119.9(7)	C(13)-C(12)-N(2)	117.9(7)

TABLE-3
HYDROGEN-BOND GEOMETRY (Å, °) OF THE TITLE COMPOUND

D–H…A	D–H	H…A	D…A	D–H…A
N(1)–H(1A)…S(2)[(1)]	0.86	2.61	3.456(6)	166
N(2)–H(2A)…O(1)[(2)]	0.86	1.92	2.630(7)	139
N(2)–H(2A)…O(2)[(3)]	0.86	2.42	3.074(8)	134
C(9)–H(9A)…S(2)[(1)(2)]	0.97	2.79	3.710(7)	158
C(18)–H(18A)…N(2)[(2)]	0.96	2.38	2.844(9)	110

Note: Elements of symmetry transformation: [(1)]1-x, -1/2+y, 1/2-z; [(2)]intermolecular hydrogen bond; [(3)]1-x, 1/2+y, 1/2-z.

TABLE-4
INSECTICIDAL ACTIVITY OF THE TITLE COMPOUND AGAINST *Ostrinia furnacalis*

Concentration (g/kg)	Corrected mortality rates (%)					
	1d	2d	3d	4d	5d	6d
0.0625	7.41	15.38	19.23	0.00	0.00	0.00
0.1250	-3.70	-7.69	-7.69	-4.35	0.00	5.00
0.2500	25.92	30.77	30.77	21.74	30.43	25.00
0.5000	29.63	26.92	26.92	17.39	26.09	15.00
1.0000	74.07	92.31	92.31	95.65	95.65	100.00

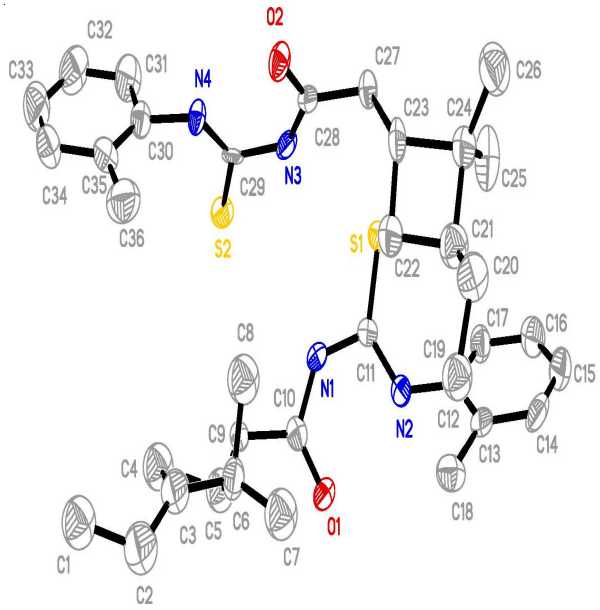

Fig. 2. View of the structure of the title compound. Ellipsoids are drawn at the 50 % probability level

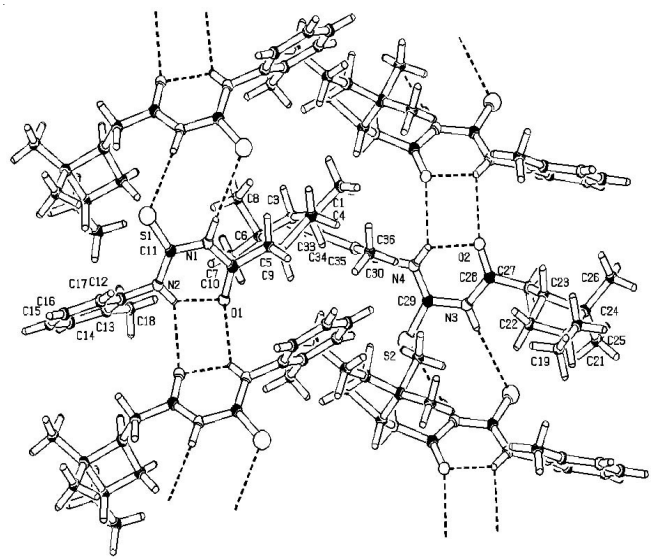

Fig. 3. The hydrogen bondings of the title compound

1.312(8) Å and 1.430(8) Å, respectively. The C-N bond length on the sides of C11=S1 bond are varied greatly. The bond length of N(2)-C(11) is shorter than that of N(1)-C(11). The reason is that the electron density of N(2)-C(11) increases due to the intramolecular hydrogen bond of N(2)-H(2A)…O(1). The bond length of C11=S1 is 1.642(7) Å longer than the normal bond length of C=S (1.56A) due to the intermolecular hydrogen bond of N(3)–H(3B)…S(1).

Insecticidal activity: The insecticidal activity of the title compound against *Ostrinia furnacalis* was measured according to the reported method[10]. The results are shown in Table-4. The toxicity regression equation of the title compound is Y = -42.71183+17.29379x. LC_{50} and LC_{95} are equal to 573.9841 mg/kg, 714.5165 mg/kg respectively. The ratio of LC_{95} and LC_{50} is 1.24. So *Ostrinia furnacalis* is sensitive to the title compound.

ACKNOWLEDGEMENTS

This work was supported by the Science and Technology Program of AQSIQ (2012QK242) and the Science and Technology Program of SDQTS (2012KYZ32).

REFERENCES

1. A.R. Hergueta, C. López, F. Fernández, O. Caamaño and J.M. Blanco, *Tetrahedron Asymm.*, **14**, 3773 (2003).
2. A.R. Hergueta, F. Fernández, C. López, J. Balzarini and E. De Clercq, *Chem. Pharm. Bull. (Tokyo)*, **49**, 1174 (2001).
3. G.A. Schmidt and G.S. Fisher, *J. Am. Chem. Soc.*, **76**, 5426 (1954).
4. Y.B. Yin, Z.Q. Song, Z.D. Wang and H.Q. Jiang, *J. Struct. Chem.*, **49**, 969 (2008).
5. P.A. Vanderhoff, H.W. Thompson and R.A. Lalancette, *Acta Crystallogr.*, **C42**, 1766 (1986).
6. R.A. Lalancette, H.W. Thompson and A.P.J. Brunskill, *Acta Crystallogr.*, **C55**, 1908 (1999).
7. A. Barcon, A.P.J. Brunskill, H.W. Thompson and R.A. Lalancette, *Acta Crystallogr.*, **C55**, 1899 (1999).
8. F.Z. Makaev, O.M. Radul, M. Gdanets, S.T. Malinovskii and A.P. Gudima, *J. Struct. Chem.*, **47**, 796 (2006).
9. M.L. Coté, H.W. Thompson and R.A. Lalancette, *Acta Crystallogr.*, **C53**, 102 (1997).
10. X.M. Ou, L.M. Tao, H. Zhang, L.L. Ji, R.H. Lin, Y.P. Ni and H. Jiang, NY/T, 1154,10 (2008).