Indian Journal of Chemistry
Vol. 60B, September 2021, pp. 1211-1214

Study of solid state structural and bonding features of (*E*)-1-(4-bromophenyl)-3-(1-*H*-indol-3-yl)-prop-2-en-1-one

Anita R Banpurkar[a], Sachin S Wazalwar*[a]& Franc Perdih[b]

[a] Department of Applied Chemistry, Rajiv Gandhi College of Engineering, Research and Technology, Chandrapur 442 403, India

[b] Faculty of Chemistry and Chemical Technology,University of Ljubljana, SI-1000 Ljubljana, Slovenia

E-mail: sacheein@gmail.com; franc.perdih@fkkt.uni-lj.si

Received 31 January 2020; accepted (revised) 18 August 2021

Single-crystal study of indolyl chalcone (*E*)-1-(4-bromophenyl)-3-(1-*H*-indol-3-yl)-prop-2-en-1-one is reported here. It has been synthesized by microwave assisted method from indole-3-carbaldehyde and 4-bromo acetophenone by Claisen-Schmidt reaction. IR,^{1}H NMR and HRMS data is reported here. The crystalline structure of this compound is described within the sp. gr. I -4; its unit cell parameters are *a* = 23.9636(17)Å,*b* = 23.9636(17)Å,*c* = 5.1428(5)Å. Crystallographic study shows formation of hydrogen-bonded cyclic tetramer around a 2-fold axis and 4-fold roto-inversion axis through N1–H1···O1 interactions between the indolic NH group as a hydrogen-bond donor and the carbonyl O atom as a hydrogen-bond acceptor.

Keywords: Indolyl chalcone, indole-3-carbaldehyde, 4-bromoacetophenone, microwave assisted, X-ray diffraction, cyclic tetramer

Indolyl chalcones have been reported to possess potent biological activities like anticancer[1,2] anti-inflammatory[2], antioxidant[2], antitumor[3] and antimicrobial[4] activities.Heterocyclic analogue is reported to be effective even against resistant cell lines[1]. Apart from biological activities it is also useful in synthesis of biologically active pyrazoles[5], flavones[6], pyrazolines[7]. Microwave assisted synthesis of chalcones is a rapid,eco-friendly and convenient method of synthesis[8]. As a part of study, we report here synthesis, characterization and single-crystal study of (*E*)-1-(4-bromophenyl)-3-(1-*H*-indol-3-yl)-prop-2-en-1-one.

Results and Discussion

The compound (*E*)-1-(4-bromophenyl)-3-(1-*H*-indol-3-yl)-prop-2-en-1-one (**3a**) was obtained by microwave assisted Claisen-Schmidt reaction between indol-3-carbaldehyde (**1a**) and 4-bromoacetophenone (**2a**) using NaOH as a catalyst and ethanol as a solvent. The yellow solid obtained in good yield. The IR spectrum of compounds **3a** shows characteristic υ(-C=O) absorption band in the region 1631 cm^{-1}, and υ(-CH=CH) band in the region 3163 cm^{-1}(Figure 1). The ^{1}H NMR spectra of compounds **3a** in DMSO exhibit characteristic singlet at 12.13 ppm attributed to indolicNH proton, doublet at 7.51 and 7.76 ppm showing one proton each is attributed to CH=CH protons representing CH=CH of chalcone moiety (Figure 2). Furthermore, the mass spectra, elemental analysis and single-crystal structure confirms the structure of compound **3a**.

We were able to obtain crystals suitable for X-ray structural analysis and crystal structure shows that all the bond lengths are within normal ranges[9] (Table I, Figure 3). Molecule is essentially planar with the maximum deviation from planarity of –0.155(9) Å for atom O1 and torsion angle between indole and phenyl ring of 2.6(5).

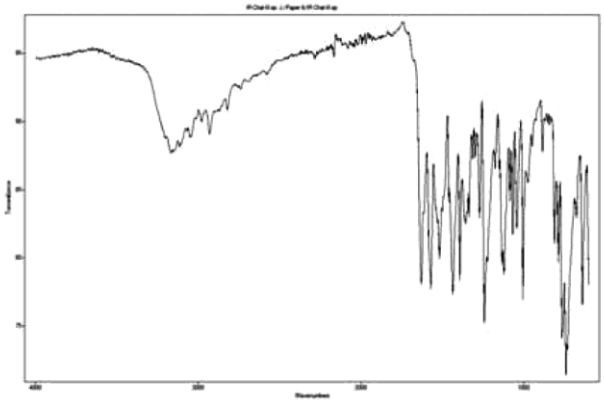


Figure 1 — FTIR spectra of compound **3a**

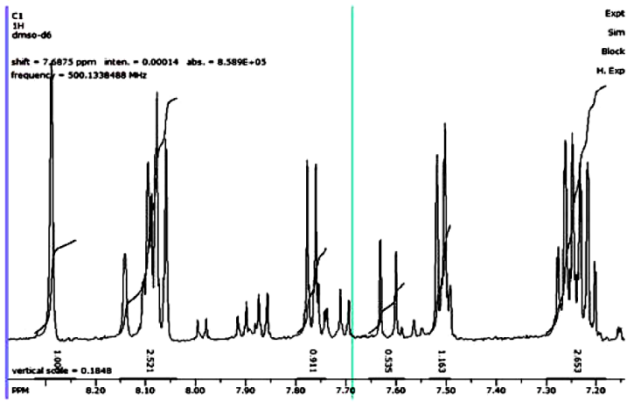


Figure 2 — ^{1}HNMR spectra of compound **3a**

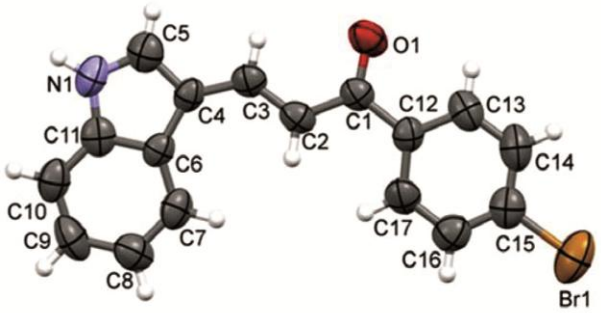


Figure 3 — Molecular structures and atom numbering scheme for 3a. Probability ellipsoids are drawn at the 50% level

Table I — Crystallographic data for compound **3a**

Compd	**3a**
CCDC number	1893165
Mol. Formula	$C_{17}H_{12}BrNO$
Mol. Wt.	326.19
Crystal System	Tetragonal
Space group	*I*–4
a (Å)	23.9636(17)
b (Å)	23.9636(17)
c (Å)	5.1428(5)
α (°)	90
β (°)	90
γ (°)	90
Z	8
V (Å^3)	2953.3(5)
D_{calc} (g cm^{-3})	1.467
μ (mm^{-1})	2.778
F(000)	1312
Reflections collected	4007
Independent reflections	2790
R_{int}	0.0249
Parameters	181
R_1, wR_2 [$I > 2\sigma(I)$][a]	0.0761, 0.1938
R_1, wR_2 (all data)[a]	0.1486, 0.2457
GOF[b]	1.006
$\Delta\rho_{min}$, $\Delta\rho_{max}$ (e Å^{-3})	0.880, –0.403

[a] $R = \sum||F_o| - |F_c||/\sum|F_o|$; $wR_2 = \{\sum[w(F_o^2 - F_c^2)^2]/\sum[w(F_o^2)^2]\}^{1/2}$. [b] $S = \{\sum[(F_o^2 - F_c^2)^2]/(n/p)\}^{1/2}$ where *n* is the number of reflections and *p* is the total number of parameters refined.

Materials and Methods

The starting materials indole-3-carbaldehyde, 4-bromoacetophenone, and solvents were purchased from commercial sources and were used without further purification. Microwave oven of Samsung, 800W output with digital timer and clock was used for synthesis. Melting point was determined in open capillary using electro thermal melting point apparatus and is uncorrected. Progress of reactions was monitored by TLC. Infrared (IR) spectra (4000–600 cm^{-1}) of the samples were recorded using a Perkin–Elmer Spectrum 100, equipped with a Specac Golden Gate Diamond ATR as a solid sample support. ^{1}H NMR spectra were recorded with a Bruker Avance III 500 NMR spectrometer with TMS as internal reference. MS spectra were recorded with an Agilent 6624 Accurate Mass TOF LC/MS instrument (ESI ionization).

Single-crystal X-ray diffraction data was collected on an Agilent Technologies SuperNova Dual diffractometer with an Atlas detector using monochromated Mo-Kα radiation (λ = 0.71073 Å) at room temperature. The data was processed using CrysAlis Pro[10]. Structure was solved by direct methods and refined on F^2 using full-matrix least-squares procedures using SHELX2014[11]. All non-hydrogen atoms were refined anisotropically. Hydrogen atoms were readily located in a difference Fourier maps and were subsequently treated as riding atoms in geometrically idealized positions, with C–H = 0.93 (aromatic and alkenyl), N–H = 0.86 Å and with U_{iso}(H) = 1.2U_{eq}(C,N). Crystallographic data are listed in Table II.

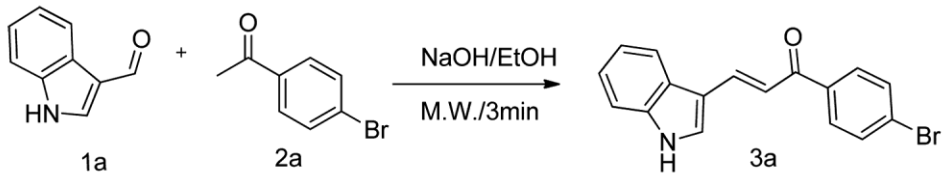
Experimental Section

Synthesis of (*E*)-1-(4-bromophenyl)-3-(1-*H*-indol-3-yl)-prop-2-en-1-one, 3a

A mixture of indol-3-carbaldehyde (1.45 g, 10 mmol), 4-bromoacetophenone (1.99 g, 10 mmol), 2-3 drops of saturated NaOH solution and ethanol (15 mL) as a solvent was irradiated to microwave for about 3 minutes at 450 watts at an interval of 5 seconds The orange yellow product so obtained was poured in crushed ice followed by acidification with 0.1 M HCl solution(Scheme I). The product obtained was filtered, dried and recrystallized using ethanol.

Table II — Hydrogen bond geometry of **3a**

D–H···A	D–H (Å)	H···A (Å)	D···A (Å)	D–H (Å)	Symmetry code
N1–H1···O1	0.86	1.97	2.824(16)	176	*y*,1 – *x*, –*z*



Scheme I — Synthesis of (*E*)-1-(4-bromophenyl)-3-(1-*H*-indol-3-yl)-prop-2-en-1-one

Table III — Bond lengths *d*(Å) and bond angles (deg) in the structure of **3a**

Bond	*d*	*Bond*	*d*
Br1–C15	1.878(14)	C6–C11	1.398(16)
O1–C1	1.272(13)	C7–C8	1.385(17)
N1–C5	1.324(18)	C8–C9	1.42(2)
N1–C11	1.366(14)	C9–C10	1.361(19)
C1–C2	1.438(17)	C10–C11	1.409(18)
C1–C12	1.468(16)	C12–C17	1.392(15)
C2–C3	1.371(16)	C12–C13	1.411(17)
C3–C4	1.392(16)	C13–C14	1.397(19)
C4–C5	1.378(17)	C14–C15	1.363(19)
C4–C6	1.416(15)	C15–C16	1.386(18)
C6–C7	1.389(16)	C16–C17	1.383(17)
Atoms	ω	Atoms	ω
C5–N1–C11	108.2(11)	C10–C9–C8	120.6(13)
O1–C1–C2	122.3(11)	C9–C10–C11	117.3(12)
O1–C1–C12	117.0(11)	N1–C11–C6	108.4(11)
C2–C1–C12	120.8(10)	N1–C11–C10	128.6(12)
C3–C2–C1	122.0(10)	C6–C11–C10	123.0(11)
C2–C3–C4	129.7(10)	C17–C12–C13	117.5(11)
C5–C4–C3	122.4(11)	C17–C12–C1	123.0(11)
C5-C4-C6	105.3(10)	C13-C12-C1	119.5(10)
C3-C4-C6	132.3(10)	C14-C13-C12	120.8(12)
N1-C5-C4	111.5(12)	C15-C14-C13	118.9(13)
C7-C6-C11	118.9(11)	C14-C15-C16	122.4(13)
C7-C6-C4	134.6(10)	C14-C15-Br1	118.6(10)
C11-C6-C4	106.6(9)	C16-C15-Br1	118.9(11)
C8-C7-C6	118.8(12)	C17-C16-C15	118.1(13)
C7-C8-C9	121.4(13)	C16-C17-C12	122.3(12)

The recrystallized product was allowed for crystal growth by slow evaporation of its saturated solution in ethanol and chloroform (1:1 v/v) in a dark chamber at room temperature[12].

Spectral data of compound 3a: Yield 87%. m.p.150°C. IR: (KBr): 3163 (CH=CH), 3046 (Ar-CH), 1631 (C=O), 1434 cm^{-1} (C=C); ^{1}H NMR (500 MHz, DMSO-d_6,): δ 7.20-7.27 (m, 3H, Ar-H), 7.51 (d, 1H, CH=CH), 7.76 (d, 1H, CH=CH), 78.05-8.14 (m, 3H, Ar-H), 8.28 (s, 1H,Ar-H), 9.93 (s, 1H, Ar-H), 12.13 (s, 1H, NH); MS (ESI+): *m/z* 326.19 (MH^+); HRMS: Calcd for $C_{17}H_{12}NO$: 326.018. Found: 325.0106.

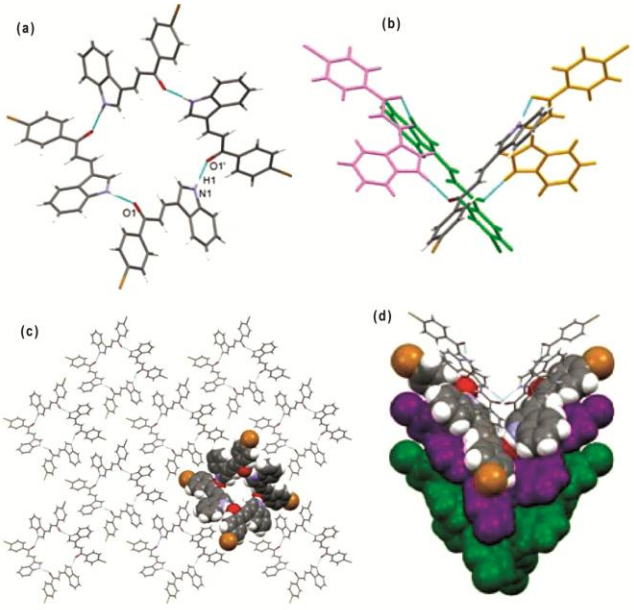


Figure 4 — (a) View along *c*-axis (top view) on hydrogen-bonded cyclic tetramer of **3a** generated by N1–H1···O1hydrogen bonding (blue dashed lines). (b) View along *a*-axis (side view) on hydrogen-bonded cyclic tetramer (color code: arbitrary colors). (c) Packing of cyclic tetramers along *c*-axis. (d) Stacking of cyclic tetramers parallel with *c*-axis (color code: arbitrary colors).

Conclusion

Chalcone**3a** was synthesized by microwave assisted Claisen-Schmidt condensation reaction with good yield. X-ray structural analysis and crystal structure shows that all the bond lengths are within normal ranges. Molecule is planar with the maximum deviation from planarity of –0.155(9) Å for atom O1 and torsion angle between indole and phenyl ring of 2.6(5)°. Formation of hydrogen-bonded cyclic tetramer around a 2-fold axis and 4-fold roto-inversion axis is observed through N1–H1···O1interactions between the indole NH group as a hydrogen-bond donor and the carbonyl O atom as a hydrogen-bond acceptor forming a $R^4_4(32)$ graph set motif. Hydrogen-bonded cyclic tetramer around a 2-fold axis and 4-fold roto-inversion axis is formed through N1–H1···O1 interactions between the indole NH group as a hydrogen-bond donor and the

carbonyl O atom as a hydrogen-bond acceptor forming a $R^4_4(32)$ graph set motif[13](Table III, Figure 4). There are noother significant hydrogen-bonding, halogen·halogen or π···π interactions present in the system. Table III shows important bond distances and bond angles in **3a**.

Supplementary Information

Supplementary information is available in the website http://nopr.niscair.res.in/handle/123456789/60.

Acknowledgments

Financial support from the Slovenian Research Agency (ARRS) through project P1-0175 is gratefully acknowledged. The authors thank the EN-FIST Centre of Excellence, Ljubljana, Slovenia, for providing access to the Super Nova diffractometer.

References

1 Sharma V, Kumar V & Kumar P, *Anti-Cancer Agents Med Chem*, 13 (2013) 422.
2 Bhale P S,Chavan H V, Dongare S B, Shingare S N, Mule Y B, Nagane S S&Bandgar B P, *Bioorg Med Chem Lett*, 27 (2017) 1502.
3 Kumar D, Kumar N M, Akamatsu K, Kusaka E, Harada H & Ito T, *Bioorg Med Chem Lett*,20 (2010) 3916.
4 Chauhan R, Dwivedi J, Anees A A S & Kishore D, *Pharm Chem J*,44 (2011) 542.
5 Sharath V, Kumar H V & Naik N, *J Pharm Res*, 6 (2013) 785.
6 Venkatesan P &Maruthavanan T, *Bull Chem Soc Ethiop*, 25 (2011) 419.
7 Siddiqui Z N, Farooq F & Mohammed Musthafa T N, *Green Chem Lett Rev*,4 (2011) 63.
8 Kakati D, Sarma R K, Saikia R, Barua N C & Sarma J C, *Steroids*, 78 (2013) 321.
9 Allen F H, Kennard O, Watson D G, Brammer L, Orpen A G & Taylor R, *J Chem Soc Perkin Trans II* (1987) S1.
10 CrysAlis PRO, Agilent Technologies, Yarnton, England (2013).
11 Sheldrick G M, *Acta Cryst*, C 71 (2015) 3.
12 Wazalwar S S, Banpurkar A R &Perdih F, *J Mol Struct*,1150 (2017) 258.
13 Bernstein J, Davis R E, Shimoni L & Chang N L, *Angew Chem Int Ed*, 34 (1995) 1555.