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CRYSTAL STRUCTURE OF *N*-(2-CYANO-1-PHENYLPROP-2-EN-1-YL)-4-METHYLBENZENESULFONAMIDE

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New allylsulfonamide is prepared in a four-step synthetic route: the Morita-Baylis-Hillman adduct prepared from benzaldehyde and acrylonitrile is acetylated using acetic anhydride and DMAP. The acetylated product reacts with DABCO displaced by the addition of 4-methylbenzenesulfonamide. The final product is characterized by high-resolution mass spectrometry, infrared, and NMR spectroscopic techniques. The X-ray crystallographic method is used to determine the crystal structure and features of the molecular structure of the compound.

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INTRODUCTION

Several compounds bearing sulfonamide groups exhibit important biological properties, such as antitumor and antimicrobial activities [1]. It has recently been discovered that allysulfonamides such as (*Z*)-*N*-(2-cyano-3-phenylprop-2-en-1-yl)-benzenesulfonamide inhibit the growth of plant pathogenic fungi [2]. Here we present the synthesis of novel allylsulfonamide bearing a terminal C=C double bond, aiming to study the influence of this structural change in the antifungal activity of this group of substances. Thus, this paper discusses the synthesis, spectroscopic characterization, and crystal structure determination of *N*-(2-cyano-1-phenylprop-2-en-1-yl)-4-methylbenzenesulfonamide.

EXPERIMENTAL

Synthesis. Morita-Baylis-Hillman aduct 2-[hydroxy(phenyl)methyl]acrylonitrile (**1**) was prepared from benzaldehyde and acrylonitrile under trimethylamine catalysis, as described in the literature [3]. Compound **1** was acetylated using acetic anhydride and 4-dimethylaminopyridine (DMAP), forming 2-cyano-1-phenylprop-2-en-1-yl acetate (**2**) [4]. A mixture of 1 mmol of 1,4-diazabicyclo[2.2.2]octane (DABCO) and 1 mmol of **2** in THF:H_2O 1:1 (6 ml) was stirred at room temperature for 30 min. Then, 2 mmol of 4-methylbenzenesulfonamide and 2 mmol of triethylamine were added and the mixture was stirred for further 8 h. The title product (**3**, 37% yield) was isolated upon extractions with CH_2Cl_2 and purified by column chromatography with silica gel (hexane/ethyl acetate 2:1). White crystals of **3** (m.p. 124.5-125.4 °C) suitable for the X-ray crystallographic analysis were obtained by recrystallization from $CHCl_3$ and petroleum ether.

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Spectroscopic data. IR (ATR; ν_{max}, cm^{-1}): 3228, 2927, 2872, 2235, 1597, 1493, 1453, 1338, 1163, 1091, 1068, 968, 957, 945, 913, 857, 844, 818, 789, 745, 732, 703, 677, 582, 549. ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.43 (s, 3H, CH_3), 5.02-5.08 (m, 2H, NH and H-1), 6.00 (d, 1H, $^2J_{HH}$ = 1.0 Hz, H-9a), 6.07 (d, 1H, $^2J_{HH}$ = 1.0 Hz, H-9b), 7.07-7.15 (m, 1H, H-5), 7.26-7.30 (m, 4H, H-3, H-4, H-6 and H-7), 7.30-7.33 (m, 2H, H-3′ and H-5′), 7.69-7.73 (d, 2H, $^3J_{HH}$ = 9.0 Hz, H-2′ and H-6′).^{13}C NMR (75 MHz, $CDCl_3$): δ 21.6 (C-7′), 59.8 (C-1), 116.5 (C-8), 123.3 (CN), 126.8 (C-2′ and C-6′), 127.3 (C-4 and C-6), 129.1 (C-5), 129.3 (C-3′ and C-5′), 129.8 (C-3 and C-7), 131.8 (C-9), 136.1 (C-2), 136.7 (C-4′), 144.1 (C-1′). HR-ESI-MS (anionic mode): Anal. Calcd. for $C_{17}H_{15}N_2O_2S^-$: 311.0854, Found: 311.0863.

X-ray crystallography. The X-ray diffraction data were collected on a Bruker APEX II-DUO diffractometer equipped with a CCD area detector and a graphite monochromator with CuK_α radiation (λ = 0.54178 Å) at 273 K. APEX II and SAINT software packages [5] were used for the unit cell determination, data collection and integration. The structure was solved using direct methods and refined successfully using full-matrix least-squares on F^2 with SHELXL-2014 [6] with anisotropic atomic displacement parameters for non-hydrogen atoms. All hydrogen atoms were stereochemically positioned and refined with the riding model. Absorption correction (GAUSSIAN) was applied for the compound using the SORTAV program [7].

The crystallographic data are as follows: chemical formula, M = 312.38, dimensions 0.344×0.262×0.262 mm, monoclinic, $P2_1/n$, a = 10.7646(3) Å, b = 11.1715(3) Å, c = 14.7311(4) Å, β = 109.7(1)°, V = 1667.5(1) Å^3, Z = 4, d_{cal} = 1.244 g/cm^3, μ = 1.790 mm^{-1}, T_{min}/T_{max} = 0.578/0.651. The resulting values are: S = 1.072, $R1$ = 0.0681 for all 3423 reflections and $R1$ = 0.0569 for 2808 reflections with $I > 2\sigma(I)$ and 212 refined parameters. The complete data of the X-ray crystallographic analysis containing atomic coordinates, bond lengths, and bond angles have been deposited at the Cambridge Crystallographic Data Centre (CCDC No. 1531585).

RESULTS AND DISCUSSION

Spectroscopic studies. The characteristic sulfonamide bands were observed at 3228 cm^{-1} (νNH), 1338 cm^{-1}, and 1163 cm^{-1} (νSO_2 asymmetric and symmetric, respectively) in the IR spectrum of compound **3**. The νCN band at 2235 cm^{-1} was shifted to higher wavenumbers with respect to precursors **1** and **2** (2229 cm^{-1} and 2228 cm^{-1}, respectively). The expected disubstituted CH_2 band was observed at 857 cm^{-1}. In the ^{1}H NMR spectrum of compound **3**, the region between δ 7.07 and 7.73 showed four multiplets integrating an area of nine hydrogen atoms due to the aromatic rings. The most important diagnostic signals were the singlet at δ 2.43 due to the methyl group and two coupled doublets (J = 1 Hz) of the methylidene group at δ 6.00 and 6.07. The H1 and NH signals superimposed at *ca.* δ 5.05. The ^{13}C NMR spectrum of compound **3** showed all the expected signals. The C=CH_2 signals were observed at δ 116.5 (C8) and 131.8 (C9), and the C1 signal at δ 129.8. The methyl and nitrile signals appeared at δ 21.6 and 123.3, respectively. The remaining signals were assigned to the aromatic carbon atoms.

X-ray structural description. Fig. 1*a* shows the ORTEP [8] drawing of the asymmetric unit of compound **3**, including the numbering scheme.

The C–C bond lengths in phenyl ring 1 (C1′ to C6′) range from 1.363(5) to 1.390(4) Å. The C4′–C7′ (1.571(4) Å) distance is longer than the other observed values in correlated compounds [9, 10]. The sulfur atom exhibits a distorted tetrahedral geometry (angles ranging from 105.3(1)° to 120.6(2)°), probably due to non-bonded intramolecular distances O1–O2, O1–N1, O2–N1, O1–C1′, and O2–C1′, resulting in structures with less steric interferences. The S–C, S=O, S–N, and N–C bond lengths present values similar to the other reported structures of sulfonamides [2, 10].

The C1–N1–S [121.9(2)°] angle is larger than the value expected for the sp^3 hybrid character of the N1 atom. The C1–C8 (1.518(3) Å) distance is consistent with the expected value for a single bond [11]. The C8–C10, C8=C9, and C10≡N2 distances are consistent with the values reported by the other authors [12]. The C–C in phenyl ring 2 (C2 to C7) and C1–C2 bond lengths are similar to the observed values in 2-chloro-2,3-diphenyl-3-(tosylamino)propionitrile [10].

The phenyl rings are essentially planar, with r.m.s.d. of 0.0042 Å (ring 1) and 0.0011 Å (ring 2) from the least-squares plane defined by the atoms. The dihedral angles between these planes is 86.8(1)°. The deviation of the C1 atom to

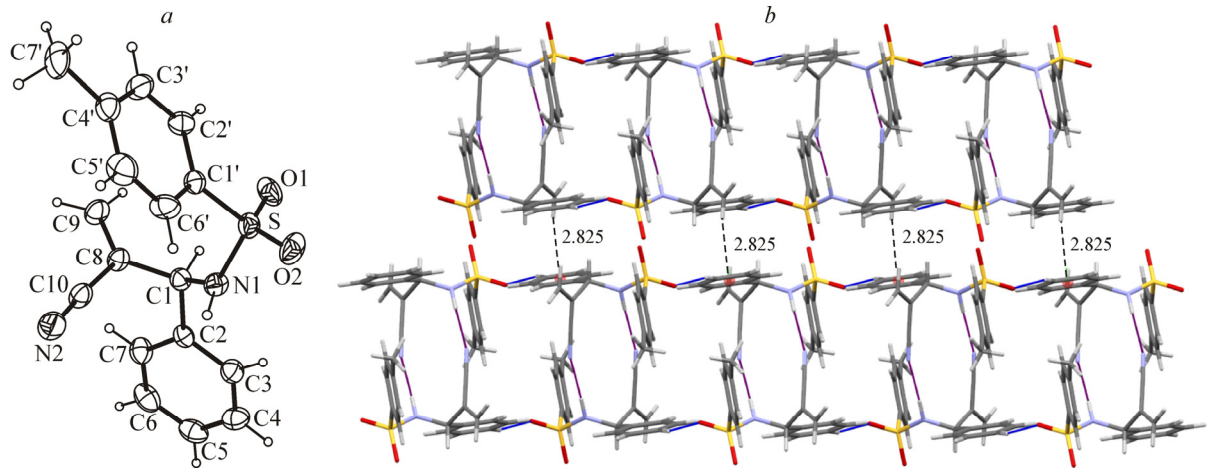

Fig. 1. ORTEP view of the compound with atom numbering scheme and displacement ellipsoids drawn at a 30% probability level (*a*); structural packing in the *b* axis direction (*b*). Dashed lines indicate C–H···O, N–H···N hydrogen bond and C–H···π interactions.

ring 1 is 0.0942(4) Å, the deviation of the C7′ and S atoms to ring 2 is 0.0027(6) Å and 0.0925(4) Å, respectively. The C1, C8, C9, C10, N2 fragment is planar with r.m.s.d. of 0.0047 Å. The dihedral angles between this plane and rings 1 and 2 are 80.1(1)° and 30.1(1)°, respectively.

The crystal packing is stabilized by two C–H···O and one C–H···N intramolecular interactions. Furthermore, pairs of N–H···N intermolecular interactions linking inversion dimers generate $R_2^2(12)$ ring motifs [13] and C–H···O intermolecular interactions connect these dimers forming chains in the *b* axis direction. The C–H···π interactions link these chains along the *a* axis, forming a three-dimensional supramolecular network (Fig. 1*b*).

To summarize, a novel allylsulfonamide has been synthesized and its structure was investigated in this study. The X-ray and the spectroscopic data proved that the position of the allylic double bond differs from the previously published analogues [2], being external to the main carbon chain. Thus, it might be interesting to compare the biological activities of these two different groups of allylsulfonamides.

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