

**SINGLE CRYSTAL X-RAY STRUCTURE OF
2-[(4-METHYLPHENYL)SULFONYLMETHYL]
AMINO)CARBONYL]-1,3-DIOXO-2,3-DIHYDRO-1H-
INDEN-2-YL 2-THIOPHENECARBOXYLATE**

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The title compound 2-[(4-methylphenyl)sulfonylmethyl]amino)carbonyl]-1,3-dioxo-2,3-dihydro-1H-inden-2-yl 2-thiophenecarboxylate is synthesized and studied by the single crystal X-ray diffraction method. The structure of the product is confirmed by IR, ¹H and ¹³C NMR spectroscopy, and mass spectrometry. The structure is solved in the *C2/c* monoclinic space group with *a* = 16.739(3) Å, *b* = 11.087(3) Å, *c* = 23.194(4) Å, β = 93.32(3)°, *V* = 4297.2(16) Å³, *Z* = 8, *R*1 = 0.033 and *wR*2 = 0.088.

Keywords: Single crystal X-ray structure, α-acyloxycarboxamide, multi-component reaction, Passerini reaction, indane-1,2,3-trione, tosylmethyl isocyanide, 2-thiophenecarboxylic acid.

INTRODUCTION

Among the known multi-component reactions, the most valuable reactions are those based on isocyanides. Isocyanide-based multi-component reactions (abbreviated to IMCRs by Ugi and Dömling) by virtue of their synthetic potential, inherent atom efficiency, convergent nature, ease of implementation, and the generation of molecular diversity have attracted much attention because of the advantages they offer to the field of combinatorial chemistry [1, 2]. Today, IMCR chemistry is mostly related to the classical reactions of Passerini and Ugi [3-6]. The Passerini reactions involve an oxo component, an isocyanide, and a nucleophile. In connection with our recent interest to isocyanide chemistry [7-12], we report the synthesis and structure of α-acyloxycarboxamide derived from the Passerini multi-component reaction between indane-1,2,3-trione, tosylmethyl isocyanide, and 2-thiophenecarboxylic acid.

EXPERIMENTAL

Melting points were measured on an Electrothermal 9100 apparatus and were uncorrected. IR spectra were measured on a Jasco FT-IR 6300 spectrometer. ¹H and ¹³C NMR spectra were measured (CDCl₃ solution) with a BRUKER DRX-250 AVANCE spectrometer at 250.0 MHz and 62.5 MHz respectively. Mass spectra were recorded on a FINNIGAN-MAT 8430 mass spectrometer operating at an ionization potential of 70 eV. Elemental analyses were performed using a Heraeus CHN-O-Rapid analyzer. The results agreed favorably with the calculated values.

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TABLE 1. Crystal Data and Structure Refinement Details for **4**

Crystallized from	<i>n</i> -heptane/CH ₂ Cl ₂	<i>F</i> (000), e	2000
Empirical formula	C ₂₃ H ₁₇ NO ₇ S ₂	Scan type	ω and φ
<i>M_r</i>	483.50	Radiation type, λ, Å	MoK _α , 0.71073
Crystal color, habit	colorless, block	Index ranges	−23 ≤ <i>h</i> ≤ 23, −15 ≤ <i>k</i> ≤ 11, −32 ≤ <i>l</i> ≤ 32
Crystal dimensions, mm	0.39×0.18×0.11	Independent reflections	6250
Temperature, K	80(2)	Reflections with <i>I</i> > 2σ(<i>I</i>)	5039
Crystal system	Monoclinic	<i>R</i> _{int}	0.035
Space group	<i>C</i> 2/ <i>c</i>	Completeness to θ = 30.0°	1.00
<i>Z</i>	8	Refinement on	<i>F</i> ²
θ range, deg	4.14–30.00	Data, restraints, parameters	6250, 10, 375
Unit cell parameters:		<i>R</i> (<i>F</i> ₀ ² > 2σ(<i>F</i> ₀ ²))	<i>R</i> 1 = 0.033, <i>wR</i> 2 = 0.088
<i>a</i> , <i>b</i> , <i>c</i> , Å; β, deg	16.739(3), 11.087(3), 23.194(4); 93.32(3)	<i>R</i> (all data)	<i>R</i> 1 = 0.044, <i>wR</i> 2 = 0.091
<i>V</i> , Å ³	4297.2(16)	Goodness-of-fit = <i>S</i>	1.047
<i>D_x</i> (calc), g·cm ^{−3}	1.495	Weighting parameter <i>a/b</i>	0.0546/0.3920
μ, mm ^{−1}	0.30	Δρ (max; min), e·Å ^{−3}	0.42; −0.36

$R1 = \sum ||F_0| - |F_c|| / \sum |F_0|$, $wR2 = \sqrt{\sum [w(F_0^2 - F_c^2)^2] / \sum [w(F_0^2)^2]}$. Weighting scheme: $w = 1/[\sigma^2(F_0^2) + (aP)^2 + bP]$, where $P = (F_0^2 + 2F_c^2)/3$.

General procedure. To a magnetically stirred solution of indane-1,2,3-trione (**1**) (0.2 mmol) and 2-thiophene-carboxylic acids (**3**) (0.2 mmol) in dry CH₂Cl₂ (5 ml) tosylmethyl isocyanide (**2**) (0.2 mmol) was added over 10 min at room temperature. The mixture was stirred at room temperature for 72 h. After completion of the reaction, the solvent was removed under reduced pressure and pure products (**4**) were obtained. The characterization data of the compound are given below.

2-([(4-Methylphenyl)sulfonyl]methyl)amino)carbonyl]-1,3-dioxo-2,3-dihydro-1*H*-inden-2-yl 2-thiophene-carboxylate (4**):** Light yellow powder, yield 90%, M.p. 207–209°C. IR (KBr): $\nu = 3433\text{ cm}^{-1}$, 3106 cm^{-1} , 3020 cm^{-1} , 2952 cm^{-1} , 1730 cm^{-1} , 1689 cm^{-1} , 1598 cm^{-1} , 1517 cm^{-1} , 1280 cm^{-1} . ¹HNMR (CDCl₃, 250 MHz): δ = 2.40 (*s*, 3H, CH₃); 4.69 (*d*, 2H, ³*J* = 6.75 Hz, NCH₂); 6.64 (*br*, 1H, NH); 7.12–8.08 (*m*, 11H, arom CH). ¹³CNMR (CDCl₃, 62.5 MHz): δ = 21.74 (CH₃); 59.76 (NCH₂); 83.62 (C–O); 124.20, 128.62, 128.91, 129.19, 130.26, 132.80, 135.27, 136.18, 136.28, 141.07, 145.64 (aromatic carbons); 158.93 (CO of ester); 162.03 (CO of amide); 189.74 (CO of ketone). MS (70 eV) *m/z* (%): 299 ([M–NHR]⁺, 43), 111 ([C₄H₃SCO]⁺, 100), 91 ([C₆H₄CH₃]⁺, 9), 76 (7). — C₂₃H₁₇NO₇S₂ (483.52): C 57.13, H 3.54, N 2.90; found C 57.02, H 3.59, N 2.95.

Crystals of **4** for the X-ray analysis were obtained by very slow evaporation of a 5:2 CH₂Cl₂/*n* — heptane solution (20–25°C) in 48 h. Light yellow single crystals were filtered off, washed with the cold solvent mixture, and dried at room temperature.

X-Ray Crystal Structure Determination of 4 (Table 1 and Fig. 1)*. The crystallographic measurement was performed on a κ-geometry *Xcalibur PX* automated four-circle diffractometer with graphite-monochromatized MoK_α radiation (λ = 0.71073 Å). The crystal data were collected at 80(2) K using the *Oxford-Cryosystems* cooler. The data were corrected for Lorentz and polarization effects. Data collection, cell refinement, and data reduction and analysis were carried out with the *Xcalibur PX* software (*Oxford Diffraction*, Poland): CrysAlis CCD and CrysAlis RED respectively [13].

*CCDC-732237 contains the supplementary crystallographic data for **4**. These data can be obtained free of charge via http://www.ccdc.cam.ac.uk/data_request/cif.

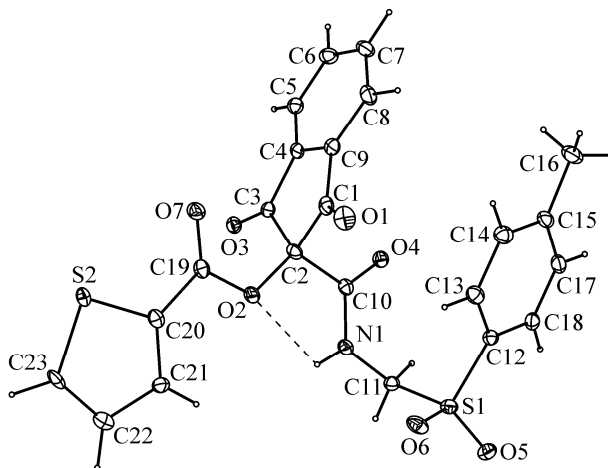
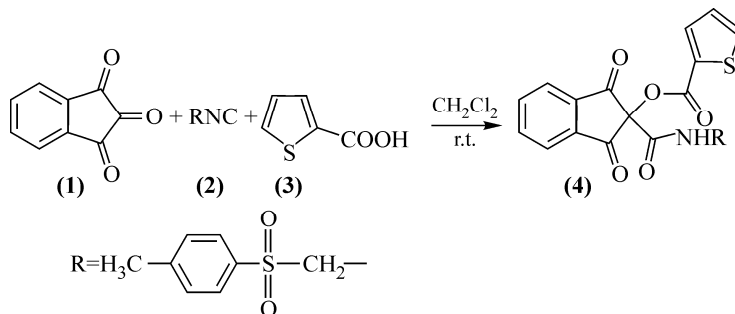


Fig. 1. Molecular structure of compound **4**, showing the X-ray atom numbering scheme and intramolecular N–H···O close contact forming S(5) motif (dashed line). Displacement ellipsoids represent the 40% probability level. For clarity only one orientation, with high s.o.f. [0.712(2)] of the disordered thiophene ring is shown.

The structure was solved by direct methods with the SHELXS-97 program [14], and refined by a fullmatrix least-squares technique with SHELXL-97 [14] and anisotropic thermal parameters for all ordered or fully occupied non-H-atoms. The thiophene ring is slightly disordered over two positions with two different orientations of the S(2) atom relative to the carbonyl O(7) atom: *syn* with a site-occupation-factor (s.o.f.) of 0.712(2) and *anti* with s.o.f. = 0.288(2). Two positions of the C(20) atom were refined with the same fractional coordinates and anisotropic displacement parameters (constraints were applied with EXYZ and EADP instructions). The remaining low-occupied positions of thiophene carbon atoms (C(210)–C(230)) were refined isotropically with U_{iso} for the C(210) atom fixed at $0.05 \text{ \AA}^2$. In the refinement procedure, some geometrical parameters of the two positions of the disordered thiophene ring (equivalent bond distances and angles) were restrained to be equal with the use of SAME instruction. All fully-occupied H atoms were found in difference Fourier maps and refined isotropically. Those from the thiophene ring were included from geometry and refined as rigid atoms with C–H distances of $0.95 \text{ \AA}$ and $U_{\text{iso}}(\text{H})$ values of $1.2U_{\text{eq}}(\text{C})$. All figures were made with the XP program [15].

RESULTS AND DISCUSSION

Indane-1,2,3-trione (**1**), tosylmethyl isocyanide (**2**), and 2-thiophenecarboxylic acid (**3**) in dichloromethane react together in a 1:1:1 ratio at room temperature to produce an α -acyloxycarboxamide derivative (**4**) (Scheme 1). The structure of the product was deduced from its IR, ^1H NMR, ^{13}C NMR, mass spectrometry, and elemental analysis.



Scheme 1

TABLE 2. Selected Interatomic Distances (Å), Bond Angles (deg) and Torsion Angles (deg) of **4**

Bond lengths			
S(1)–O(5)	1.4438(10)	S(2)–C(20)	1.682(2)
S(1)–O(6)	1.4447(10)	S(2)–C(23)	1.711(3)
S(1)–C(11)	1.806(2)	N(1)–C(10)	1.346(2)
S(1)–C(12)	1.754(2)	N(1)–C(11)	1.435(2)
Bond angles			
O(5)–S(1)–O(6)	119.45(6)	O(6)–S(1)–C(12)	108.67(6)
O(5)–S(1)–C(11)	106.73(6)	C(12)–S(1)–C(11)	103.23(6)
O(6)–S(1)–C(11)	106.95(6)	C(20)–S(2)–C(23)	91.96(9)
O(5)–S(1)–C(12)	110.51(6)	C(10)–N(1)–C(11)	121.60(10)
Torsion angles			
O(5)–S(1)–C(11)–N(1)	170.43(8)	C(11)–N(1)–C(10)–C(2)	–175.4(1)
O(6)–S(1)–C(11)–N(1)	41.50(10)	C(10)–N(1)–C(11)–S(1)	100.9(1)
C(12)–S(1)–C(11)–N(1)	–73.05(9)	O(1)–C(1)–C(2)–O(2)	37.7(2)
O(5)–S(1)–C(12)–C(18)	33.6(1)	O(1)–C(1)–C(2)–C(10)	–83.4(2)
O(6)–S(1)–C(12)–C(18)	166.47(9)	C(9)–C(1)–C(2)–C(3)	–17.6(1)
C(11)–S(1)–C(12)–C(18)	–80.2(1)	C(2)–C(1)–C(9)–C(4)	13.3(2)
C(19)–O(2)–C(2)–C(1)	56.9(2)	O(2)–C(2)–C(10)–(4)	172.9(1)
C(19)–O(2)–C(2)–C(10)	176.65(9)	C(3)–C(2)–C(10)–O(4)	47.8(2)
C(2)–O(2)–C(19)–O(7)	–0.9(2)	S(2)–C(20)–C(19)–O(7)	2.2(2)
C(2)–O(2)–C(19)–C(20)	179.05(9)		

Crystal structure of 4. A summary of the conditions for the data collection and the structure refinement parameters are given in Table 1. The values of bond lengths and valence angles (Table 2) correspond well with those typical of the respective types of chemical connections [16]. The molecular structure of the compound reveals three planar regions (Fig. 1). These are: plane 1 extending from the thiophene ring to the methylene C(11) atom (with a r.m.s. of fitted atoms = 0.112 Å), plane 2 defined by the 1,3-dioxo-2,3-dihydro-1*H*-indenyl moiety (r.m.s. = 0.112 Å), and plane 3 formed by the S(1) atom and the toluene part from the (4-methylphenyl)sulfonyl group (r.m.s. = 0.069 Å). The thiophene ring is slightly disordered over two positions with two different orientations of the S(2) atom relative to the carbonyl O(7) atom. Site occupation factors determined for the two orientations reveal that over 70% of the molecules in the crystal of compound **4** exist in *syn* conformation (with the S(2)–C(20)–C(19)–O(7) torsion angle of 2.2(2)°), which is shown in Fig. 1. The analogous S(20)–C(200)–C(19)–O(7) torsion angle is –176.8(3)°.

The planar amide moiety [N(1)–C(10) bond of 1.346(2) Å] is in *trans* conformation, which is reflected in the value of the C(11)–N(1)–C(10)–C(2) torsion angle of –175.4(1)°. It is possible that the mutual orientation of these two planar regions of the molecule, i.e. 2-thiophenecarboxylate and the amide moieties, is stabilized by the intramolecular N(1)–H(1)···O(2) hydrogen bond (Fig. 1, Table 3) forming the *S*(5) motif and resulting in the planarity of this part of the molecule. The discussed plane 1 is almost perpendicular to plane 2 (1,3-dioxo-2,3-dihydro-1*H*-indenyl group), with the dihedral angle between planes 1 and 2 amounting to 88.3(1)°. At the same time, plane 1 is twisted at 25.9(1)° relative to plane 3.

The only hydrogen contact formed by the N(1) atom is the intramolecular N(1)–H(1)···O(2) hydrogen bond stabilizing the overall structure of compound **4** (Fig. 1). Apart from that, there are no more donors of classic hydrogen bonds present in the molecule of the compound, and thus, no such intermolecular interactions are possible. Instead, the crystal structure of **4** is stabilized by a three-dimensional network of weak intermolecular C–H···O contacts, in which most of the oxygen atoms act as acceptors (only the O(5) atom is not involved; Table 3). Among them two centrosymmetric hydrogen bonds formed by the methylene C(11) group may be of importance for the crystal structure of **4**. Both C(11)–H(11*A*)···O(3)ⁱⁱ

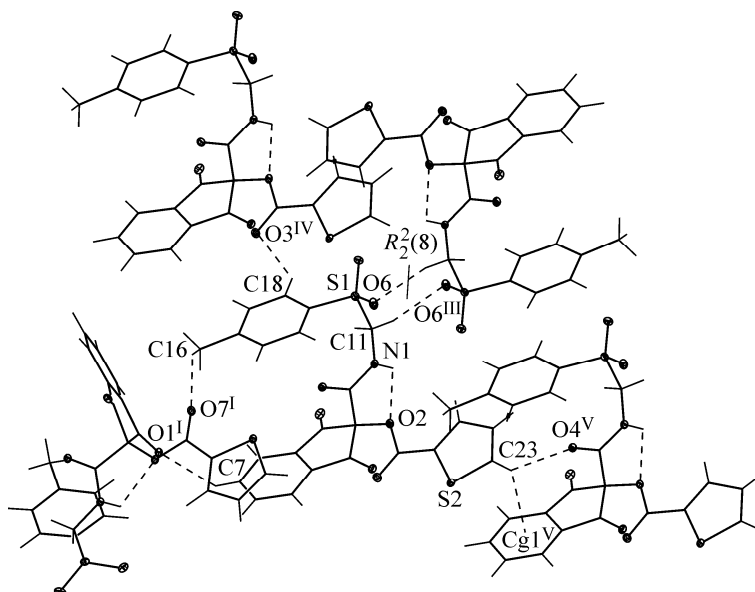


Fig. 2. Arrangement of **4** within the three-dimensional network of weak C–H $\cdots$ O/ π interactions. Intra- and intermolecular contacts are shown with dashed lines. Symmetry codes are given in Table 3.

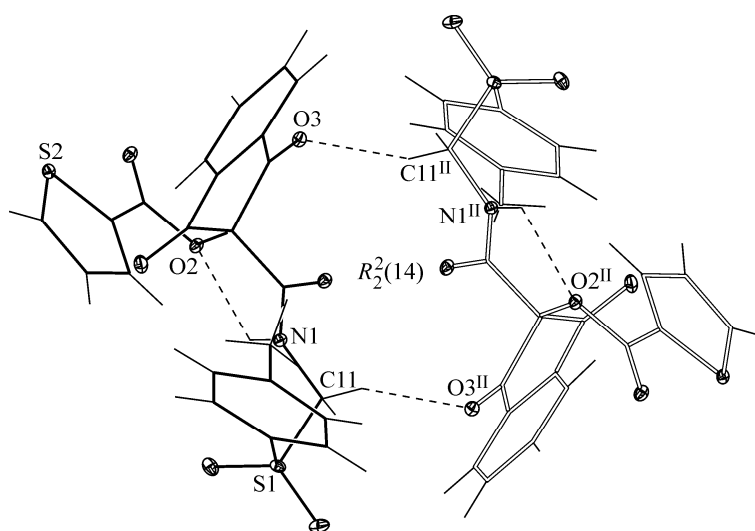


Fig. 3. Two molecules of **4** related by a centre of inversion, linked by the C–H $\cdots$ O interactions (dashed lines) forming the R_2^2 (14) ring motif. Symmetry codes are given in Table 3.

and C(11)–H(11*B*) $\cdots$ O(6)ⁱⁱⁱ interactions, involving two adjacent molecules related by a centre of inversion, give rise to ring motifs: R_2^2 (8) (shown in Fig. 2) and R_2^2 (14) (Fig. 3) respectively. As shown in Fig. 2, the adjacent molecules related by the action of 2_1 screw axes and a direct translation are joined to each other by the extensive network of weaker C–H $\cdots$ O as well as C–H $\cdots$ π contacts (Table 3). In this way, the respective dimers are linked into a three-dimensional network, the fragment of which is shown in Fig. 2. Additionally, some close O $\cdots$ π (ring) contacts are observed in the crystal of **4**. The engaged oxygen atoms are O(4), O(5), and O(7); the O $\cdots$ Cg (π -thiophene/toluene ring) distances range from 3.504(2) Å to 3.716(2) Å; C/S $\cdots$ Cg (π -ring) distances range from 3.910(2) Å to 4.288(2) Å, and C/S=O $\cdots$ Cg (π -ring) angles are in the 98.7(1)–120.3(1) $^\circ$ range.

TABLE 3. Geometry of Proposed N/C–H···O/ π Close Contacts for **4**

D–H···A	D–H, Å	H···A, Å	D···A, Å	D–H···A, deg	Offset, Å
N(1)–H(1)···O(2)	0.87(2)	2.16(2)	2.576(2)	109(2)	—
C(7)–H(7)···O(1) ⁱ	0.94(2)	2.43(2)	3.214(2)	140(2)	—
C(11)–H(11A)···O(3) ⁱⁱ	0.97(2)	2.51(2)	3.437(2)	160(2)	—
C(11)–H(11B)···O(6) ⁱⁱⁱ	0.93(2)	2.32(2)	3.169(2)	151(2)	—
C(16)–H(16C)···O(7) ⁱ	0.97(2)	2.67(2)	3.459(2)	139(2)	—
C(18)–H(18)···O(3) ^{iv}	0.98(2)	2.56(2)	3.096(2)	114(1)	—
C(23)–H(23)···O(4) ^v	0.95	2.47	3.210(3)	135	—
C(230)–H(230)···O(4) ^v	0.95	2.61	3.276(4)	128	—
C(23)–H(23)···Cg(1) ^v	0.95	2.96	3.704(3)	136	0.34

Symmetry codes: (i) $-x+1/2, y+1/2, -z+3/2$; (ii) $-x+1/2, -y+3/2, -z+1$; (iii) $-x+1, -y+1, -z+1$; (iv) $x+1/2, y+1/2, z$; (v) $x, y-1, z$. Cg(1) is the centroid of the C(4)–C(9) phenylene ring.

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