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The synthesis and crystal structure of (4*E*)-5-(3-chlorophenyl)-*N*-(4-chlorophenyl)-2-diazo-3-oxopent-4-enoic acid amide

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(4*E*)-5-(3-Chlorophenyl)-*N*-(4-chlorophenyl)-2-diazo-3-oxopent-4-enoic acid amide (**5**) was synthesized from *p*-chloroaniline to *N*-(4-chlorophenyl)-2-diazo-3-oxo-butyramide (**4**) with 3-chlorobenzaldehyde. The yielded product **5** was investigated with X-ray crystallographic, NMR, MS, and IR techniques. Compound **5** ($C_{17}H_{11}Cl_2N_3O_2$, Formula wt = 360.19), crystallizes in the monoclinic space group $P21/c$ with unit cell parameters $a = 10.516(2)$, $b = 17.996(4)$, $c = 8.902(2)$ Å, $\alpha = 90.00$, $\beta = 105.36(3)$, $\gamma = 90.00^\circ$. $V = 1624.5(6)$ Å^3, $Z = 4$, $D_x = 1.473$ Mg m^{-3}. The final R was 0.0511.

KEY WORDS: Crystal structure; diazodicarbonyl compound; 2-diazo-3-oxopent-4-enoic acid amide; synthesis; ethyl (acetoketal)acetate; (2-methyl-[1,3]dioxolan-2-yl)acetic acid ethyl ester.

Introduction

In recent years in various publications, certain compounds having a 1,2,3-triazole nucleus have been reported as antibacterials,[1] antifungals,[2] antivirals,[3] anti-inflammatories and analgesics.[4] Recently, some new 1,3,4-triazole derivatives have been synthesized as possible anticonvulsants[5] and plant growth regulators[6]; and 1,2,3-triazole derivatives have been synthesized to inhibit tumor proliferation, invasion, metastasis,[7] and have shown anti-HIV activity.[8–13] Likewise, the pyrone nucleus derivatives have been synthesized which have shown anti-HIV activity.[14–19] The fused benzopyrone derivatives show various biological effects, such as anti-HIV activity.[9,20] For this reason, the heterocyclic derivatives containing two 1,2,3-triazoles, and pyrone nucleus are very interesting, we also demonstrated that the new title compounds of pyrono[3,2-d]1,2,3-triazole containing more heterocycles can be studied, but their properties have not been published in the literature till now. We have reported the crystalline structure of 5-[5-amino-1-(4-chlorophenyl)-1,2,3-triazol-4-yl]-2-(3-bromoanilino)-1,3,4-thiadiazole and their derivatives,[21–23] the crystalline structure of 3-[5-methyl-1-(4-methylphenyl)-1,2,3-triazol-4-yl]-*s*-triazolo[3,4-b]-1,3,4-thiadiazole.[24] When we concentrate on synthesis of 4-acetyl-1-(*p*-chlorophenyl)-5-hydroxyl-1,2,3-triazole by reaction of *p*-chlorophenyl azide with ethyl (acetoketal)acetate or (2-methyl-[1,3]-dioxolan-2-yl)-acetic acid ethyl ester, *N*-(4-chlorophenyl)-2-diazo-3-oxo-butyramide is obtained. In subsequent reaction of the compound with

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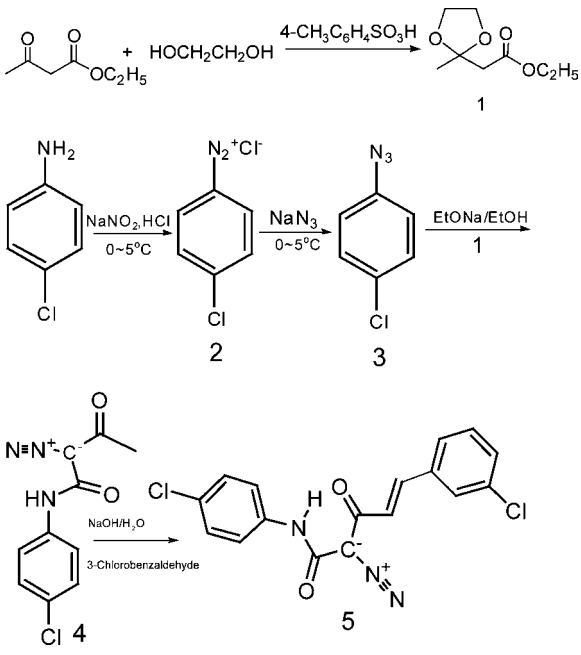
3-chlorobenzaldehydes, we obtained (4*E*)-5-(3-chlorophenyl)-*N*-(4-chlorophenyl)-2-diazo-3-oxopent-4-enoic acid amide which resulted in the triazole ring opened in acidic water. A great deal of interest has been focused on the α-diazocarbonyl compounds.[25] When properly substituted, they can be useful materials for photoresist. This has inspired us to extend our work on α-diazodicarbonyl compounds *N*-(4-chlorophenyl)-2-diazo-3-oxobutyramide with heterocyclic opening in order to study the synthesis and potential applications of (4*E*)-5-(3-chlorophenyl)-*N*-(4-chlorophenyl)-2-diazo-3-oxopent-4-enoic acid amides.

In this paper, we report the synthesis and crystalline structure of (4*E*)-5-(3-chlorophenyl)-*N*-(4-chlorophenyl)-2-diazo-3-oxopent-4-enoic acid amide (**5**).

The route of synthesis is shown in Scheme 1.

Experimental section

Melting points were uncorrected and determined on an XT_4-100× microscopic melting point apparatus. IR spectra were obtained in KBr discs on a Nicolet 170SX FT-IR spectrometer. MS were performed on an HP-5988A spectrometer (EI at 70 eV). ^{1}H NMR spectroscopy ($CDCl_3$) were recorded on an Avance Mercury plus-300 MHz instrument with TMS as an internal standard.



Scheme 1.

2-(Methyl-[1,3]-dioxolan-2-yl)-acetic acid ethyl ester (**1**) was prepared following the method reported in the literature.[26]

A mixture of ethyl acetoacetate (13.0 g, 0.1 mol), ethylene glycol (50 mL), PTS (50 mg) and benzene (100 mL) was refluxed with continuous removal of water azeotropically for 8 h. The reaction mixture was cooled and neutralized with aqueous K_2CO_3 (5 mL). The reaction mixture was diluted with water (100 mL) and benzene layer was separated. The aqueous phase was extracted with benzene (2 × 100 mL), the obtained benzene layers were combined, dried (Na_2SO_4), and distilled. The obtained residue was distilled under reduced pressure to give as viscous colorless liquid (in 90% yield).^{1}H NMR δ_H: 4.04–4.16 (q, 2H, J = 7.2 Hz, OCH_2CH_3); 3.93 (s, 4H, $-OCH_2CH_2O-$); 2.62 (s, 2H, $-CCH_2CO_2-$); 1.46 (s, 3H, CH_3-); 1.19–1.26 (t, 3H, J = 7.2 Hz, CH_2-CH_3) ppm.

N-(4-Chlorophenyl)-2-diazo-3-oxobutyramide was prepared from *p*-chloroaniline following the method reported in the literature.[27]

The solution of sodium ethoxide (3.5 g, 0.15 mol of sodium in 50 mL of ethanol) was added to a solution of 15.3 g (0.1 mol) *p*-chlorophenyl azide and 12.0 mL (0.1 mol) ethyl (acetoketal)acetate (**1**) in 80 mL absolute ethanol in one portion under ice bath. Then, the reaction mixture was heated under refluxed for 48 h. The solution was cooled to room temperature, and the solvent was removed in vacuo to give a syrup mixture. This mixture was dissolved in 100 mL water and acidified to pH = 1∼2 with hydrochloric acid (4 M). After stirring in an ice-bath for 1 h, the resulting precipitate was filtered off and washed with water and recrystalized from ethanol to give 16 g compound **4**. Yield 65%, mp 145–146°C (Lit. 143°C), IRυ_{max}: 3236, (b, −N−H), 3069

(Ar—H), 3027, 2938, (w, CH_3), 2125(s, diazo), 1670, 1638 (s, C=O, —CONH—), 1596, 1548, 1488 (s, Ar), 953, 841, 820 (m, Ph-1,2H), 722 (C—Cl) cm^{-1}. ^1H NMR δ_H: 10.22 (b, 1H, NH); 7.52–7.55 (d, 2H, $J = 7.2$ Hz, Ph-2,6H); 7.30–7.27 (d, 2H, $J = 7.2$ Hz, Ph-3,5H); 2.43 (s, 3H, CH_3—) ppm. MS *m/z*: 237 (M^+, 21), 239 (M+2, 7), 194(4), 181(9), 167(10), 153(6), 138(54), 127(14), 111(28), 99(21), 83(44), 75(28), 69 (5), 63(19), 55(14), 50(11), 43(100), 39(10).

(4*E*)-5-(3-chlorophenyl) - *N* -(4-chlorophenyl)-2-diazo-3-oxopent-4-enoic acid amide (**5**) was prepared by the following method.

Compound **4** (1.5 g) was added to a solution of sodium hydroxide (0.8 g) and 20 mL 50% ethanol (V/V), then 3-chlorobenzaldehyde was added dropwise to the solution with continuous stirring at room temperature. The reaction mixture was stirred at room temperature for 8 h, acidified to pH = 7∼8 with HCl (4M), the deposit was filtered and recrystalized from ethanol to give **5**. Yield 87%, mp 159–160°C, IRυ_{max}: 3224, (b, —N—H), 3179, 3110 (Ar—H), 3060, 2938, (w, CH_3), 2120 (s, diazo), 1668, 1641 (s, C=O, —CONH—), 1576, 1543, 1490 (s, Ar), 975, 830 (m, Ph-1, 2H), 925, 789, 789 (m, chlorophyl 1H or 3H), 738, 692 (C—Cl)cm^{-1}. ^1H NMR δ_H: 10.58 (b, 1H, NH); 7.72–7.77 (d, 1H, $J = 15$ Hz, C11—H); 7.29–7.55 (m, 8H, Ar—H); 6.88–6.89 (d, 1H, $J =$ 15 Hz, C10—H) ppm. MS *m/z*: 359 (M^+, 15.3%), 361(M+2, 10.2%), 278(0.4), 276(0.8), 274(1.9), 233(3), 207(3), 205(9), 195(2.5), 193(7), 182(2), 180(7), 178(16), 167(20), 165(52), 151(21), 149(52), 131(21), 127(47), 125(24), 115(54), 111 (50), 91(16), 77(18), 69(70), 57(93), 43(100).

The purified product was dissolved in a mixture of ethyl acetate, petroleum ether solvent. The crystal was obtained after 10 day by evaporation of the solvent.

Crystal structure determinations and refinement

Single crystals were selected and mounted on the tip of a glass fiber. Preliminary examination and data collection were performed with Mo$K\alpha$ radiation ($\lambda = 0.71073$ Å) on an Enraf–Nonius CAD4 computer-controlled kappa axis diffractometer operating in the $\omega/2\theta$ scanning mode. The structure was determined by direct methods (SHELXS-97)[28] and refined by full covariance matrix methods (SHELXL-97).[29] The crystal data, data collection and the refinement parameter for the structure are given in Table 1.

The structure of the title compound is shown in Fig. 1. Selected bond lengths and angles are given in Table 2. The geometric calculations were performed using the program SHELX-97.

Results and discussion

The structure of the title compound **5** is shown in Fig. 1. In recent years, the synthesis and

Table 1. Crystal Data and Summary of Data Collection and Structure Refinement

Compound	$C_{17}H_{11}Cl_2N_3O_2$
CCDC deposit no.	250506
Color	Colorless
Formula weight	360.19
Temperature (K)	20(293)
Crystal system	Monoclinic
Space group	*P*21/*c*
Unit cell dimensions	
a (Å)	10.516(2)
b (Å)	17.996(4)
c (Å)	8.902(2)
Volume (Å^3)	1624.5(6)
Z	4
D_{calc} (g/cm^3)	1.473
F(000)	736
Absorption coefficient (mm^{-1})	0.414
Diffractometer/scan	Enraf–Nonius CAD4, $\omega/2\theta$
Radiation/λ (Å)	$k\alpha$ (graphite monochromator)/ 0.71073
θ_{min}, θ_{max} (°)	5.98–25.03
Reflections measured	2997
Independent/observedreflections	1593
Data/restraints/parameters	2810/0/218
Refinement method Full-matrix least-squares on	F^2
Goodness-of-fit on F^2	1.028
Shift/su_max	0.094
Final *R* indices	$R_1 = 0.0511$, $wR_2 = 0.1184$
R indices [$I > 2\sigma(I)$]	$R_1 = 0.1171$, $wR_2 = 0.1340$
Largest diff. peak and hole (eÅ^{-3})	0.218 and −0.184

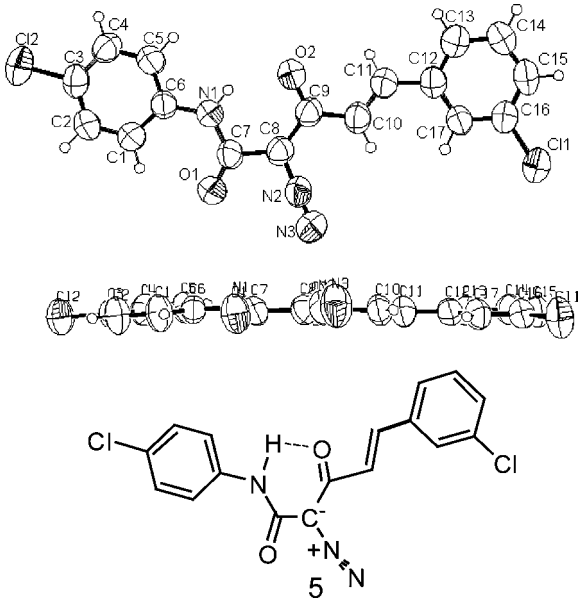


Fig. 1. ORTEP drawing of the title compound **5** showing the atom numbering scheme (ellipsoids: 50% probability).

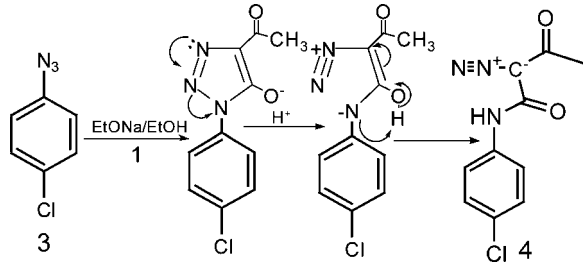
characteristics of 5-amino-1-(4-chlorophenyl)-1,2,3-triazol-4-yl and 5-methyl-1-(4-methylphenyl)-1,2,3-triazol-4-yl derivatives have been investigated.[21–24] These heterocyclic compounds contain 1,2,3-triazole ring, and they was a series stable compounds. In order to continuate our studies, we now report the crystal structure of (4*E*)-5-(3-chlorophenyl)-*N*-(4-chlorophenyl)-2-diazo-3-oxopent-4-enoic acid amide (**5**).

We isolated compound **4** that was formed from the ring opening product using 4-acetyl-1-(4-chlorophenyl)-5-hydroxy-1, 2, 3 -triazole in acid medium. We claim that the reaction mechanism is the following formation under the reaction conditions in Scheme 2. The reaction mechanism is in agreement with literature that reported the reaction mechanism.[27,30] We have known that the structure has something to do with the medium.

Identified as a diazo compound showing strong IR absorption at 2125 cm^{-1} of **4** and 2120 cm^{-1} of **5**, there is no 1,2,3-triazole ring system in molecular structure of compounds.[27] The bond length of N2—N3 (1.116(6) Å) in compound **5** are not in agreement with the values reported for 1,2,3-triazole ring. The bond length is shorter than N=N [N1—N2 1.361(5) Å; N2—N3 1.295(5) Å] in 1,2,3-triazole ring.

Table 2. Selected Bond Lengths (Å) and Angles (°)

Atoms	Length (Å)	Atoms	Angle (°)
Cl1—C16	1.737(6)	C7—N1—C6	127.0(4)
Cl2—C3	1.755(5)	N3—N2—C8	175.4(5)
O1—C7	1.206(6)	C6—C1—C2	120.5(5)
O2—C9	1.238(6)	C3—C2—C1	119.0(5)
N1—C7	1.356(6)	C2—C3—C4	122.2(5)
N1—C6	1.404(6)	C2—C3—Cl2	119.0(4)
N2—N3	1.116(6)	C4—C3—Cl2	118.8(5)
N2—C8	1.326(7)	C3—C4—C5	118.0(5)
C1—C6	1.370(7)	C4—C5—C6	121.5(5)
C1—C2	1.374(7)	C1—C6—C5	118.8(5)
C2—C3	1.360(8)	C1—C6—N1	124.3(5)
C3—C4	1.360(8)	C5—C6—N1	116.9(4)
C4—C5	1.372(7)	O1—C7—N1	127.0(5)
C5—C6	1.376(7)	O1—C7—C8	120.7(5)
C7—C8	1.484(7)	N1—C7—C8	112.3(4)
C8—C9	1.443(8)	N2—C8—C9	118.4(5)
C9—C10	1.465(7)	N2—C8—C7	110.9(4)
C10—C11	1.309(7)	C9—C8—C7	130.6(5)
C11—C12	1.460(7)	O2—C9—C8	118.7(5)
C12—C17	1.380(7)	O2—C9—C10	121.0(5)
C12—C13	1.381(8)	C8—C9—C10	120.3(5)
C13—C14	1.391(7)	C11—C10—C9	121.1(5)
C14—C15	1.371(8)	C10—C11—C12	128.4(5)
C15—C16	1.358(8)	C17—C12—C13	118.2(5)
C16—C17	1.366(7)	C17—C12—C11	123.2(5)
		C13—C12—C11	118.5(5)
		C12—C13—C14	121.1(5)
		C15—C14—C13	119.1(5)
		C16—C15—C14	119.5(5)
		C15—C16—C17	121.9(5)
		C15—C16—Cl1	118.6(4)
		C17—C16—Cl1	119.5(4)
		C16—C17—C12	120.0(5)



Scheme 2.

The ring system and all of atoms are in the plane in intramolecular, so there is the conjugate of the $\pi-\pi$. It is shown in Fig. 1.

These are the interactions of hydrogen bond on the molecular stacking [N1—H1A 0.90 H1A···O2 1.95 N1—H1A···O2 2.697(5) Å N1—H1A···O2 139.7(°)].

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