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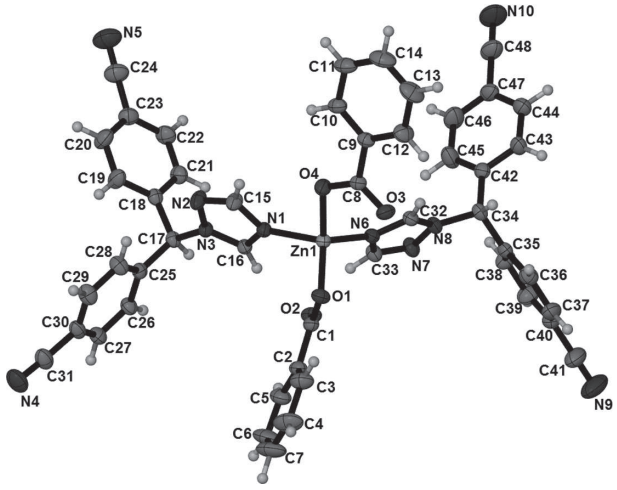
# Crystal structure of bis(benzoato-κ*O*)bis(4,4′-((1*H*-1,2,4-triazol-1-yl)methylene)dibenzonitrile-κ*N*)zinc(II), $C_{48}H_{32}N_{10}O_4Zn$

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## Abstract

$C_{48}H_{32}N_{10}O_4Zn$, monoclinic, $P2_1/c$ (no. 14), $a = 18.661(7)$ Å, $b = 12.003(4)$ Å, $c = 21.043(8)$ Å, $\beta = 111.632(4)°$, $V = 4381(3)$ Å$^3$, $Z = 4$, $R_{gt}(F) = 0.0539$, $wR_{ref}(F^2) = 0.1210$, $T = 293$ K.

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The crystal structure is shown in the figure. Tables 1 and 2 contain details of the measurement method and a list of the atoms including atomic coordinates and displacement parameters.

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**Table 1:** Data collection and handling.

| | |
|---|---|
| Crystal: | Colourless prism |
| | size 0.50 × 0.15 × 0.10 mm |
| Wavelength: | Mo $K_\alpha$ radiation (0.71073 Å) |
| $\mu$: | 6.2 cm$^{-1}$ |
| Diffractometer, scan mode: | Rigaku CCD, $\varphi$ and $\omega$ |
| $2\theta_{max}$, completeness: | 56°, >99 % |
| $N(hkl)_{measured}$, $N(hkl)_{unique}$, $R_{int}$: | 49684, 10071, 0.044 |
| Criterion for $I_{obs}$, $N(hkl)_{gt}$: | $I_{obs} > 2\ \sigma(I_{obs})$, 7429 |
| $N(param)_{refined}$: | 568 |
| Programs: | SHELX [5] |

**Table 2:** Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å$^2$).

| Atom | *x* | *y* | *z* | $U_{iso}$*/$U_{eq}$ |
|---|---|---|---|---|
| Zn1 | 0.024173(16) | 0.71286(2) | 0.294170(14) | 0.04800(10) |
| O1 | 0.00404(11) | 0.61182(16) | 0.21658(8) | 0.0620(5) |
| O2 | −0.01107(12) | 0.77855(17) | 0.16890(9) | 0.0676(5) |
| O3 | 0.13526(11) | 0.56713(16) | 0.37519(9) | 0.0659(5) |
| O4 | 0.03279(11) | 0.64802(17) | 0.38248(9) | 0.0659(5) |
| N1 | −0.07519(11) | 0.79781(17) | 0.28120(10) | 0.0487(5) |
| N2 | −0.18358(13) | 0.8389(2) | 0.29814(12) | 0.0710(7) |
| N3 | −0.17450(11) | 0.90672(17) | 0.24965(10) | 0.0492(5) |
| N4 | −0.54448(19) | 0.7804(3) | −0.04506(17) | 0.1069(11) |
| N5 | −0.2953(3) | 1.2685(3) | 0.4753(2) | 0.1288(14) |
| N6 | 0.11453(11) | 0.81663(17) | 0.31135(10) | 0.0499(5) |
| N7 | 0.18636(13) | 0.95667(19) | 0.29639(12) | 0.0649(6) |
| N8 | 0.22948(11) | 0.88425(18) | 0.34563(10) | 0.0536(5) |
| N9 | 0.4814(3) | 0.9990(5) | 0.1473(2) | 0.171(2) |
| N10 | 0.3917(3) | 1.2372(4) | 0.6615(2) | 0.1615(19) |
| C1 | −0.01697(14) | 0.6756(2) | 0.16391(13) | 0.0542(6) |
| C2 | −0.05111(16) | 0.6228(3) | 0.09570(13) | 0.0614(7) |
| C3 | −0.0511(2) | 0.5091(3) | 0.08770(17) | 0.0841(10) |
| H3 | −0.0276 | 0.4624 | 0.1263 | 0.101* |
| C4 | −0.0856(3) | 0.4624(4) | 0.0228(2) | 0.1206(16) |
| H4 | −0.0858 | 0.3840 | 0.0167 | 0.145* |
| C5 | −0.08606(19) | 0.6902(3) | 0.03914(15) | 0.0797(9) |
| H5 | −0.0856 | 0.7688 | 0.0445 | 0.096* |
| C6 | −0.1212(3) | 0.6444(4) | −0.02421(17) | 0.1134(15) |
| H6 | −0.1467 | 0.6907 | −0.0625 | 0.136* |
| C7 | −0.1194(3) | 0.5316(5) | −0.0322(2) | 0.1304(18) |
| H7 | −0.1419 | 0.5004 | −0.0766 | 0.156* |
| C8 | 0.09392(15) | 0.5904(2) | 0.40786(12) | 0.0515(6) |
| C9 | 0.11603(15) | 0.5537(2) | 0.48043(12) | 0.0536(6) |
| C10 | 0.07413(17) | 0.5874(2) | 0.51909(13) | 0.0638(7) |
| H10 | 0.0294 | 0.6320 | 0.4988 | 0.077* |

**Table 2** (continued)

| Atom | x | y | z | $U_{iso}$*/$U_{eq}$ |
|---|---|---|---|---|
| C11 | 0.0965(2) | 0.5569(3) | 0.58687(16) | 0.0826(10) |
| H11 | 0.0669 | 0.5796 | 0.6128 | 0.099* |
| C12 | 0.18132(19) | 0.4891(3) | 0.51057(16) | 0.0770(9) |
| H12 | 0.2106 | 0.4647 | 0.4846 | 0.092* |
| C13 | 0.2036(2) | 0.4601(3) | 0.57947(18) | 0.0984(12) |
| H13 | 0.2486 | 0.4164 | 0.6007 | 0.118* |
| C14 | 0.1609(3) | 0.4947(3) | 0.61641(17) | 0.0948(12) |
| H14 | 0.1765 | 0.4748 | 0.6633 | 0.114* |
| C15 | −0.12216(16) | 0.7759(2) | 0.31516(14) | 0.0637(7) |
| H15 | −0.1116 | 0.7191 | 0.3489 | 0.076* |
| C16 | −0.11055(13) | 0.8812(2) | 0.24013(12) | 0.0487(6) |
| H16 | −0.0925 | 0.9169 | 0.2086 | 0.058* |
| C17 | −0.23137(13) | 0.9929(2) | 0.21414(12) | 0.0496(6) |
| H17 | −0.2054 | 1.0453 | 0.1925 | 0.059* |
| C18 | −0.25181(14) | 1.0597(2) | 0.26697(13) | 0.0512(6) |
| C19 | −0.31617(18) | 1.0398(3) | 0.28203(17) | 0.0761(9) |
| H19 | −0.3527 | 0.9860 | 0.2563 | 0.091* |
| C20 | −0.3287(2) | 1.0965(3) | 0.33390(18) | 0.0851(10) |
| H20 | −0.3733 | 1.0805 | 0.3439 | 0.102* |
| C21 | −0.20224(17) | 1.1423(2) | 0.30312(15) | 0.0660(7) |
| H21 | −0.1584 | 1.1599 | 0.2923 | 0.079* |
| C22 | −0.2150(2) | 1.1999(3) | 0.35455(16) | 0.0769(9) |
| H22 | −0.1801 | 1.2567 | 0.3786 | 0.092* |
| C23 | −0.27756(19) | 1.1759(3) | 0.37128(15) | 0.0693(8) |
| C24 | −0.2878(3) | 1.2291(3) | 0.4287(2) | 0.0939(11) |
| C25 | −0.29917(14) | 0.9427(2) | 0.15703(13) | 0.0509(6) |
| C26 | −0.32436(15) | 0.9936(2) | 0.09378(13) | 0.0611(7) |
| H26 | −0.2985 | 1.0581 | 0.0870 | 0.073* |
| C27 | −0.38684(16) | 0.9520(3) | 0.04005(15) | 0.0693(8) |
| C28 | −0.33759(17) | 0.8484(2) | 0.16586(15) | 0.0675(8) |
| H28 | −0.3205 | 0.8118 | 0.2089 | 0.081* |
| C29 | −0.40002(18) | 0.8076(3) | 0.11282(17) | 0.0738(8) |
| H29 | −0.4264 | 0.7435 | 0.1194 | 0.089* |
| C30 | −0.42449(16) | 0.8598(3) | 0.04998(15) | 0.0654(7) |
| C31 | −0.4912(2) | 0.8155(3) | −0.00416(19) | 0.0814(9) |
| C32 | 0.18625(14) | 0.8030(2) | 0.35430(12) | 0.0500(6) |
| H32 | 0.2040 | 0.7440 | 0.3864 | 0.060* |
| C33 | 0.11758(15) | 0.9109(2) | 0.27711(14) | 0.0599(7) |
| H33 | 0.0737 | 0.9414 | 0.2421 | 0.072* |
| C34 | 0.31308(14) | 0.9002(2) | 0.38210(13) | 0.0552(6) |
| H34 | 0.3343 | 0.8276 | 0.4044 | 0.066* |
| C35 | 0.35066(14) | 0.9241(2) | 0.33071(13) | 0.0552(6) |
| C36 | 0.38329(18) | 0.8377(3) | 0.30737(15) | 0.0714(8) |
| H36 | 0.3828 | 0.7642 | 0.3239 | 0.086* |
| C37 | 0.41682(19) | 0.8586(3) | 0.25970(17) | 0.0847(10) |
| H37 | 0.4390 | 0.7992 | 0.2433 | 0.102* |
| C38 | 0.35254(18) | 1.0300(3) | 0.30647(16) | 0.0732(8) |
| H38 | 0.3308 | 1.0900 | 0.3226 | 0.088* |
| C39 | 0.3856(2) | 1.0496(3) | 0.25914(17) | 0.0864(10) |
| H39 | 0.3859 | 1.1230 | 0.2423 | 0.104* |
| C40 | 0.41804(18) | 0.9649(4) | 0.23611(15) | 0.0799(9) |
| C41 | 0.4536(3) | 0.9847(5) | 0.1861(2) | 0.1186(15) |
| C42 | 0.32949(15) | 0.9863(2) | 0.43918(13) | 0.0564(6) |
| C43 | 0.39892(17) | 0.9800(3) | 0.49233(15) | 0.0740(8) |
| H43 | 0.4359 | 0.9267 | 0.4908 | 0.089* |
| C44 | 0.41626(19) | 1.0494(3) | 0.54778(16) | 0.0823(10) |
| H44 | 0.4649 | 1.0435 | 0.5842 | 0.099* |
| C45 | 0.2790(2) | 1.0671(3) | 0.44067(19) | 0.0948(11) |
| H45 | 0.2314 | 1.0750 | 0.4032 | 0.114* |
| C46 | 0.2963(2) | 1.1386(3) | 0.4967(2) | 0.1032(12) |
| H46 | 0.2610 | 1.1954 | 0.4971 | 0.124* |
| C47 | 0.3644(2) | 1.1263(3) | 0.55102(17) | 0.0782(9) |
| C48 | 0.3798(2) | 1.1911(4) | 0.6117(2) | 0.1107(14) |

## Source of material

A mixture of letrozole (4,4′-((1*H*-1,2,4-triazol-1-yl)methylene) dibenzonitrile; 285 mg, 1 mmol), benzoic acid (122 mg, 1 mmol) and $Zn(OH)_2$ (50 mg, 0.5 mmol), was placed into a 25 mL steel vessel with a 15 mm steel ball. 0.1 mL methanol was added. The mixture was ground with a LAB WIZZ 320 ball mill at 30 Hz for 30 min. The obtained powder was collected and dried. Colourless single crystals could be obtained by recrystallizing the powder in methanol.

## Experimental details

The structures were solved by direct methods and refined using the SHELXTL program package [5]. H atoms on C atoms were located geometrically (C–H = 0.95 or 1.00 Å) with $U_{iso}(H) = 1.2\,U_{eq}(C)$.

## Discussion

Moulton explored a complementary approach to the synthesis of pharmaceutical cocrystals by introducing second ligands to form mixed-ligand metal complexes of APIs [1]. In fact, many cocrystal formers such as carboxylic acids are ideal second ligand for ternary supramolecular complexes of APIs. The secondary ligands could be expected to tailor the properties of APIs as they do likewise in pharmaceutical cocrystals [2]. Letrozole is an aromatase inhibitor used in the treatment of diseases such as infertility [3]. In the molecular structure, there exist a triazole ring which could theoretically form robust synthons involved in O—H···N hydrogen-bonding interactions with carboxylic acids such as benzoic acid [4]. We carried out cocrystallization experiments of letrozole with benzoic acid by liquid-assisted grinding. As a result, no cocrystal has been obtained. Hence, we attempted to introduce trace element Zn(II) ion for preparing ternary complex of letrozole with benzoic acid as second ligand. As a result, we obtained the expected ternary complex, [Zn(II)(letrozole)$_2$(benzoate)$_2$].

There is one neutral mononuclear complex in the asymmetric unit. The Zn(II) center is in a tetrahedron coordination environment consisting of two letrozole molecules and two benzoates. The two N atoms are coordinated to Zn(II) with a distance of 2.044(2) Å and 2.019(2) Å, respectively. The carboxylate O atoms from benzoate anions are coordinated by mono-coordination with a distance of 1.9559(18) Å and 1.9659(19) Å, respectively. The geometric arrangement of letrozole and benzoate resulted in a non-centrosymmetric mononuclear complex. There exist C–H···O interactions between adjacent mononuclear units. Uncoordinated carboxylate O from one benzoate anion interacts with two C–H groups from letrozole.

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## References

1. Ma, Z.; Moulton, B.: Supramolecular medicinal chemistry: Mixed-ligand coordination complexes. Mol. Pharm. **4** (2007) 373–385.
2. Lou, B.; He, F.: Coordination polymers as potential solid forms of drugs: three zinc(II) coordination polymers of theophylline with biocompatible organic acids. New. J. Chem. **37** (2013) 309–316.
3. Tulandi, T.; Martin, J. ; Al-Fadhli, R.; Kabli, N.; Forman, R.; Hitkari, J.; Librach, C.; Greenblatt, E.; Casper, R. F.: Congenital malformations among 911 newborns conceived after infertility treatment with letrozole or clomiphene citrate. Fertil. Steril. **85** (2006) 1761–1765.
4. Varughese, S.; Azim, Y.; Desiraju, G.R.: Molecular complexes of alprazolam with carboxylic acids, boric acid, boronic acids, and phenols. Evaluation of supramolecular heterosynthons mediated by a triazole ring. J. Pharm. Sci. **99** (2010) 3743–3753.
5. Sheldrick, G. M.: A short history of SHELX. Acta Crystallogr. **A64** (2008) 112–122.