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SHORT COMMUNICATION

**Stereospecific ligands and their complexes. Part XIV. Crystal structure of the *O,O'*-dipropyl ester of *N,N'*-1,2-ethanediybis-L-leucine, dihydrochloride**

JELENA M. VUJIĆ<sup>1</sup>, SANTIAGO GARCIA-GRANDA<sup>2</sup>, LAURA MENENDEZ-TABOADA<sup>2</sup>, SLADANA B. NOVAKOVIĆ<sup>3</sup> and SREĆKO R. TRIFUNOVIĆ<sup>4\*\*</sup>

<sup>1</sup>Faculty of Agronomy, University of Kragujevac, Cara Dušana 34, 32000 Čačak, Serbia, <sup>2</sup>University of Oviedo, Faculty of Chemistry, Oviedo, Spain, <sup>3</sup>Vinča Institute of Nuclear Sciences, Condensed Matter Physics Laboratory, University of Belgrade, P. O. Box 522, 11001 Belgrade, Serbia and <sup>4</sup>Department of Chemistry, Faculty of Science, University of Kragujevac, Radoja Domanovića 12, 34000 Kragujevac, Serbia

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**Abstract:** The bidentate *N,N'*-ligand precursor, the *O,O'*-dipropyl ester of *N,N'*-1,2-ethanediybis-L-leucine, dihydrochloride, [(*S,S*)-H<sub>4</sub>eddl]Cl<sub>2</sub>, was prepared and its crystal structure is given herein. It crystallizes in a *P*<sub>4</sub><sub>2</sub> space group of a tetragonal crystal system with *a* = 16.5620 (2) Å, *b* = 16.5620 (2) Å, *c* = 5.2240 (1) Å and *Z* = 2.

**Keywords:** crystal structure; tetragonal crystal system; *O,O'*-dipropyl ester of *N,N'*-1,2-ethanediybis-L-leucine, dihydrochloride.

INTRODUCTION

R<sub>2</sub>edda-type esters (edda = the ion of ethylenediamine-*N,N'*-diacetic acid) are of interest as ligands for a variety of opportunities for coordination of metal ions. Recently, the synthesis and characterization of platinum(II) and platinum(IV) complexes with *N,N'*-bidentate R<sub>2</sub>eddp (R<sub>2</sub>eddp = *O,O'*-dialkyl ethylenediamine-*N,N'*-dipropionate) and halide ligands were reported.<sup>1–6</sup> The work was extended by synthesizing chiral branched-chain esters, (*S,S*)-R<sub>2</sub>eddp, and the corresponding platinum(II/IV) complexes.<sup>7</sup> Furthermore, most of the prepared ligands were used for the synthesis of the corresponding palladium(II) complexes.<sup>8–10</sup> Some of complexes, especially platinum(II) and platinum(IV) with *N,N*-bidentates, have demonstrated significant antitumoral activity.<sup>2–7</sup>

\* Corresponding author. E-mail: srecko@kg.ac.rs

# Serbian Chemical Society member.

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Although a large number of R<sub>2</sub>edda-type esters have been synthesized up to now, it was only possible to obtain single crystals suitable for X-ray analysis in the case of *O,O'*-diisopropyl ester of *N,N'*-1,2-ethanediylbis-L-alanine.<sup>7</sup>

The preparation and spectral characterization of the *O,O'*-dipropyl ester of *N,N'*-1,2-ethanediylbis-L-leucine, dihydrochloride was published earlier.<sup>8</sup> This paper reports the single crystal X-ray structure determination of *O,O'*-dipropyl ester of *N,N'*-1,2-ethanediylbis-L-leucine, dihydrochloride, [(*S,S*)-H<sub>2</sub>Pr<sub>2</sub>eddl]Cl<sub>2</sub>.

## EXPERIMENTAL

### Chemistry

All reagents were of purity grade. *N,N'*-1,2-Ethanediylbis-L-leucine, dihydrochloride, [(*S,S*)-H<sub>4</sub>eddl]Cl<sub>2</sub>, was prepared as previously reported.<sup>11</sup>

*Synthesis of O,O'-dipropyl ester of N,N'-1,2-ethanediylbis-L-leucine, dihydrochloride, [(S,S)-H<sub>2</sub>Pr<sub>2</sub>eddl]Cl<sub>2</sub>.*

The ester was prepared using a previously described esterification reaction.<sup>8</sup> The ester was recrystallized from the warm 1-propanol and after cooling to room temperature and standing for several days, single crystals suitable for X-ray measurements were obtained.

### X-Ray crystal structure determination

The diffraction data from a selected single crystal of [(*S,S*)-H<sub>2</sub>Pr<sub>2</sub>eddl]Cl<sub>2</sub> were collected at room temperature on an Oxford Diffraction Xcalibur Gemini S diffractometer equipped with CuK $\alpha$  radiation ( $\lambda = 1.54184 \text{ \AA}$ ). The data were processed with CrysAlis software<sup>12</sup> and corrected for absorption by an analytical numeric method.<sup>13</sup> The crystal structure was solved by direct methods using Sir2002<sup>14</sup> and refined using SHELXL.<sup>15</sup> The refinement of the crystal structure revealed high isotropic displacement parameters for the carbon atoms of the propyl ester group, indicating severe disorder of this fragment. All attempts to model the disorder were unsuccessful and the temperature factors of the propyl ester C atoms were refined as isotropic. All H atoms were placed at the geometrically calculated positions with the D–H distances fixed at 0.98, 0.97 and 0.96  $\text{\AA}$  from C(sp<sup>3</sup>) of methine, methylene and methyl, respectively, and at 0.90  $\text{\AA}$  from the N atom. The corresponding isotropic displacement parameters of the hydrogen atoms were equal to 1.2 $U_{\text{eq}}$  and 1.5 $U_{\text{eq}}$  of the parent C and N atoms. Geometrical calculations were performed with PARST97<sup>16</sup> and molecular graphics with ORTEP<sup>17</sup> and Mercury.<sup>18</sup> Details of the X-ray structural analysis are given in Table I.

TABLE I. Crystal data and structure refinement for [(*S,S*)-H<sub>2</sub>Pr<sub>2</sub>eddl]Cl<sub>2</sub>

Empirical formula	C <sub>20</sub> Cl <sub>2</sub> H <sub>42</sub> O <sub>4</sub> N <sub>2</sub>
Formula weight	445.47
Wavelength, $\text{\AA}$	1.54184
Crystal system	Tetragonal
Space group	<i>P</i> 4 <sub>2</sub>
Unit cell dimensions	
<i>a</i> = <i>b</i> / $\text{\AA}$	16.562(2)
<i>c</i> / $\text{\AA}$	5.224(1)
<i>Z</i>	2
$\mu$ / mm <sup>-1</sup>	2.215
<i>V</i> / $\text{\AA}^3$	1432.9(3)

TABLE I. Continued

F(000)	484
$D_{\text{calc}} / \text{g cm}^{-3}$	1.032
Temperature, K	293
Crystal size, $\text{mm}^3$	$0.07 \times 0.02 \times 0.01$
Reflections collected	8570
Independent reflections	2869
Absolute structure parameter	0.05(6)
Goodness-of-fit on $F^2$	0.814
$R_{\text{int}}$	0.0663
$R_1, wR_2 [I > 2\sigma(I)]$	0.0769, 0.1911

## RESULTS AND DISCUSSION

The title compound (Fig. 1) crystallizes in the chiral space group  $P4_2$  with one-half of the molecule representing the asymmetric unit. The molecular halves are related by a twofold axis that passes through the mid-point of the central C10–C10<sup>i</sup> bond ( $i = -x + 1, -y, z$ ). The charge of the protonated ester molecule is balanced by chloride anions. Selected geometrical parameters are given in Table II. According to the values of the torsion angles C7–C6–C5–N1, C6–C5–N1–C10, C5–N1–C10–C10<sup>i</sup> and N1–C10–C10<sup>i</sup>–N1<sup>i</sup>, which range from  $-167.2(9)$  to  $-178.8(8)^\circ$ , the conformation of the aliphatic chain can be described as fully extended. The atoms of the C5/C6/C7/N1/C10 fragment are co-planar within  $0.037(6)$  Å. A similar extended conformation of the chain and the co-planarity of the constituent atoms were observed in previously reported R<sub>2</sub>edda-type esters.<sup>7,9,10</sup> In the present compound, the dihedral angle between the C5/C6/C7/N1/C10 best planes from the two molecular halves is equal to  $32.6(5)^\circ$ , indicating a slight mutual twist through the molecular center. Although severe dis-

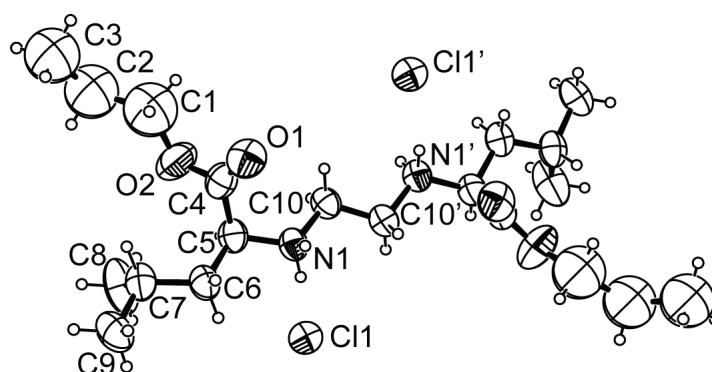


Fig. 1. Molecular structure of [(*S,S*)-H<sub>2</sub>Pr<sub>2</sub>eddl]Cl<sub>2</sub> with the atom labeling scheme. The displacement ellipsoids are plotted at the 40 % probability level. The twofold axis passes through the middle of C10–C10' bond.

order prevents the clear localization of the C atoms of the propyl ester group, one can observe that the planar ester fragment C5/C4/O1/O2 (rms deviation of fitted atoms is 0.01) takes a significant turn with respect to the C5/C6/C7/N1/C10 plane. The dihedral angle formed between the corresponding best planes is equal to 74.1(3)°.

TABLE II. Selected bond lengths and angles

Bond lengths, Å		Bond angles, °	
C4–O1	1.479(18)	C5–C6–C7	113.5(6)
C4–O2	1.324(10)	C4–C5–N1	107.0(6)
C5–N1	1.491(8)	C5–N1–C10	115.8(5)
C5–C6	1.541(9)	O1–C4–O2	125.7(9)
C6–C7	1.531(9)	C5–C4–O1	127.4(8)

The molecular conformation is stabilized by two rather weak and bent intramolecular hydrogen bonds formed between the diamine and isopropyl C–H groups as donors and the oxygens of the ester group as acceptors (Table III). The crystal packing is, as expected, dominated by the hydrogen bonds formed between the charged components, the protonated amino nitrogen and the Cl anion. Both available N–H fragments of the amino group are utilized in the hydrogen bonding. These two rather strong N–H···Cl interactions (Table III) connect the molecules into a ribbon. In addition to the N–H···Cl hydrogen bonds, the molecules are interconnected by C5–H···O1 interactions (Fig. 2a). Although regarded as a secondary interaction, the C5–H···O1 displays a favorable directionality (Table III). Owing to the twofold symmetry, the molecules generate an identical set of interactions running in the opposite direction and reinforcing the connection between them. In general, two molecules inside the ribbon are connected with: four N–H···Cl interactions forming a motif described by Etter's graphset notation<sup>19</sup> as R<sup>4</sup><sub>2</sub>(14) and two C–H···O interactions forming a larger ring-like motif described as R<sup>2</sup><sub>2</sub>(18) (Fig. 2a). The interactions link the parallel molecules in the *c* direction; however taking into account the molecule length and its extended conformation, one can observe that the formed molecular ribbon expands through the entire *ac* plane. The described N–H···Cl hydrogen bonds, which engage the most polar parts of the molecules, are the main non-covalent interactions in this crystal structure. Similar contacts, leading to a similar molecular arrangement, were also observed in the crystal packing of two previously reported R<sub>2</sub>edda·2HCl esters.<sup>7,9</sup> In the present crystal structure, the ribbons related by a fourfold axis direct their propyl ester fragments each to another, maximizing the nonbonding C–H contacts. As a result, the formation of a three-dimensional porous structure, with the parallel non-polar channels extended in the *c* direction, can be observed (Fig. 2b).

TABLE III. Hydrogen bonding geometry ( $\text{\AA}$  and  $^\circ$ ). Symmetry codes: *i*)  $x, y, z$ ; *ii*)  $x, y, z+1$ 

Bond	D–H	D...A	H...A	D–H...A
C7–H7...O2 <sup><i>i</i></sup>	0.98	3.111(11)	2.57	114
C10–H10a...O1 <sup><i>i</i></sup>	0.97	3.119(10)	2.58	115
N1–H1a...Cl1 <sup><i>i</i></sup>	0.90	3.133(8)	2.25	166
N1–H1b...Cl1 <sup><i>ii</i></sup>	0.90	3.106(8)	2.25	158
C5–H5...O1 <sup><i>ii</i></sup>	0.98	3.303(10)	2.35	164

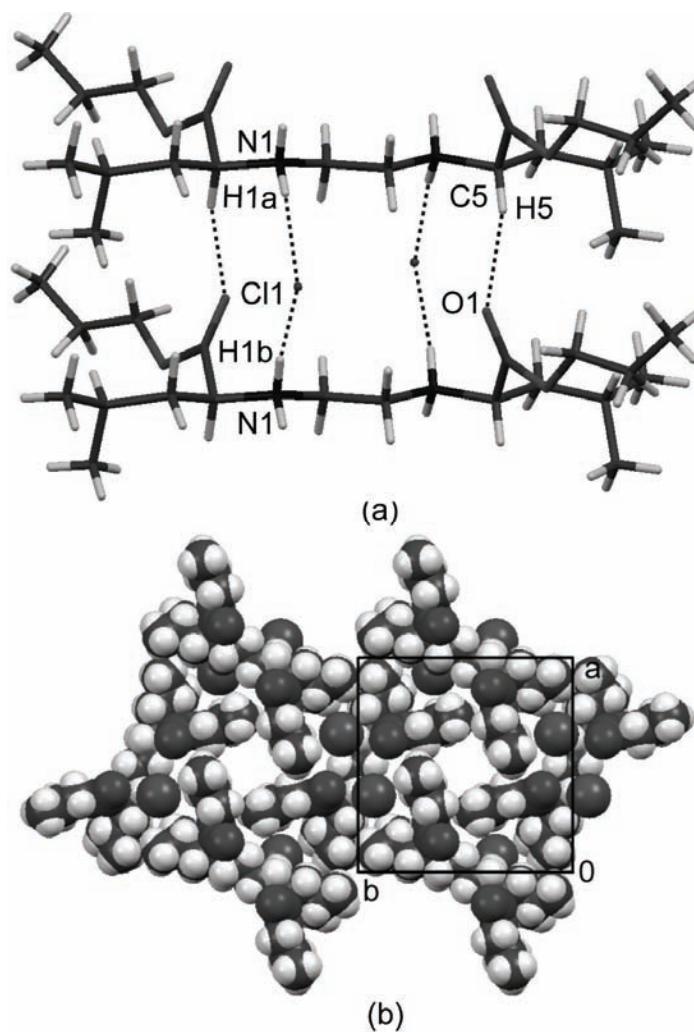


Fig. 2. a) Inter-molecular N–H...Cl and C–H...O hydrogen bonding relates the molecules into ribbons; b) segment of the three-dimensional porous crystal structure.

## CONCLUSIONS

*O,O'*-Dipropyl ester of *N,N'*-1,2-ethanediybis-L-leucine was crystallized in the form of the dihydrochloride in a  $P4_2$  space group of a tetragonal crystal system. The crystal form and the crystal packing are determined by strong intermolecular  $N1-H1a\cdots Cl1$ ,  $N1-H1b\cdots Cl1$  and  $C5-H5\cdots O1$  hydrogen bonds.

*Supplementary data.* CCDC 863095 contains the supplementary crystallographic data to this paper. These data can be obtained free of charge via [www.ccdc.cam.ac.uk/conts/retrieving.html](http://www.ccdc.cam.ac.uk/conts/retrieving.html) (or from the Cambridge Crystallographic Data Centre, 12, Union Road, Cambridge CB21EZ, UK; fax: +44 1223 336033).

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## ИЗВОД

СТЕРЕОСПЕЦИФИЧНИ ЛИГАНДИ И ЊИХОВИ КОМПЛЕКСИ. ДЕО XIV. КРИСТАЛНА СТРУКТУРА *O,O'*-ДИПРОПИЛ ЕСТРА *N,N'*-1,2-ЕТАНДИИЛБИС-*L*-ЛЕУЦИН-ДИХИДРОХЛОРИДА

ЈЕЛЕНА М. ВУЈИЋ<sup>1</sup>, SANTIAGO GARCIA-GRANDA<sup>2</sup>, LAURA MENÉNDEZ-TABOADA<sup>2</sup>,  
СЛАЂАНА Б. НОВАКОВИЋ<sup>3</sup> И СРЕЂКО Р. ТРИФУНОВИЋ<sup>4</sup>

<sup>1</sup>Агрономски факултет, Универзитет у Крајеву, Цара Душана 34, 32000 Чачак, <sup>2</sup>University of Oviedo, Faculty of Chemistry, Oviedo, Spain, <sup>3</sup>Институт за нуклеарне науке „Винча“, Лабораторија за физику кондензоване материје, Универзитет у Београду, б. бр. 522, 11001 Београд и <sup>4</sup>Институт за хемију, Природно-математички факултет, Универзитет у Крајеву, Радоја Домановића 12, 34000 Крајевац

Синтетисан је бидентатни *N,N'* лиганд прекурсор, *O,O'*-дипропил естар *N,N'*-1,2-етандиилбис-*L*-леуцин-дихидрохлорида, и испитивана је његова кристална структура. Наведени лиганд кристалише у просторној групи  $P4_2$  тетрагоналног кристалног система са димензијама јединичне ћелије  $a = 16.5620$  (2) Å,  $b = 16.5620$  (2) Å,  $c = 5.2240$  (1) Å и  $Z = 2$ .

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