NOTE

Study on Novel Structure of Europium Complex

HAI-XING LIU^{1,*}, QING-HUA ZHANG¹, HUAN-MEI GUO¹, JING-ZHONG XIAO^{2,*}, XI-SHI TAI¹, GUANG ZENG³ and KAI-QI YE⁴

¹Chemistry & Chemical and Environmental Engineering College, Weifang University, Weifang 261061, P.R. China

²CEMDRX, Department of Physics, University of Coimbra, Coimbra 3004-516, Portugal

³State Key Laboratory of Inorganic Synthesis and Preparative Chemistry, College of Chemistry, Jilin University, Changchun 130012, P.R. China

⁴State Key Laboratory of Supramolecular Structure and Materials, College of Chemistry, Jilin University, Changchun 130012, P.R. China

*Corresponding authors: E-mail: haixingliu@tom.com; jxiao@ua.pt

(Received: 24 January 2013;

Accepted: 28 November 2013)

AJC-14454

A novel europium complex with the m.f. $C_{10}H_{21}Eu_2NO_{19}$ has been synthesized from a hydrothermal reaction and the crystal structure has been determined by means of single-crystal X-ray diffraction. Europium atom is coordinated by nine O atoms. The molecular structure stabilized by the O-H...O and O-H...N hydrogen-bonding interactions.

Key Words: Europium complex, Structure analysis.

Lanthanide complexes have attracted attention of researchers for interesting structures and potential applications in luminescent materials, catalysts and magnetic molecular materials, *etc.*¹⁻⁵. Among lanthanide ions, europium(III) ion has received the most attention because of good luminescence with narrow bandwidth, large stokes shift and long luminescence lifetime. The Eu complexes are successfully applied in materials science as luminescent probes and sensory materials⁶. carboxylates are often used to construct the coordination polymers because of their rich coordination modes^{7,8}. A large number of lanthanide carboxylate complexes have been reported with dimeric or 1-, 2- and 3-D polymeric structures due to variable coordination number of Ln(III) as well as coordination versatility of carboxylate⁹⁻¹³. In this paper, the novel Eu complex is reported.

All commercially obtained reagent-grade chemicals were used without further purification. A mixture of Eu_2O_3 (0.01 mmol, 0.004 g), dilute HNO_3 , 2,2'-bipyridine (0.1 mmol, 0.016 g), K_2CrO_4 (0.1 mmol, 0.02 g), boric acid (0.1 mmol, 0.006 g) and tartaric acid (0.2 mmol, 0.03 g) were added into 20 mL water with 10 % (v/v) ethanol and heated for 6 h at 413 K. The solution was obtained by filtration after cooling the reaction to room temperature. Yellow block single crystals suitable for X-ray measurements were obtained after a few weeks.

The crystal structure of title europium complex with the m.f. $C_{10}H_{21}Eu_2NO_{19}$ is shown in Fig. 1. The crystal data and structure refinement is shown in Table-1. The Eu atom is

TABLE-1
CRYSTAL DATA AND STRUCTURE
REFINEMENT FOR THE TITLE COMPLEX

Empirical formula	$C_{10}H_{21}Eu_2NO_{19}$
Formula weight	763.20
Temperature	293(2) K
Wavelength	0.71073 Å
Crystal system, space group	Monoclinic, P2(1)/c
Unit cell dimensions	$a = 11.0821(12)$ Å, $\alpha = 90^\circ$, $b = 9.6205(9)$ Å, $\beta = 114.204(2)^\circ$, $c = 10.1103(10)$ Å, $\gamma = 90^\circ$
Volume	$983.15(17)$ Å ³
Z, Calculated density	2, 2.578 Mg/m ³
Absorption coefficient	6.421 mm ⁻¹
$F_{(000)}$	732
Crystal size	0.43 mm $\times$ 0.40 mm $\times$ 0.39 mm
Theta range for data collection	3.06 - 25.02°
Limiting indices	$-13 \leq h \leq 13$, $-11 \leq k \leq 11$, $-12 \leq l \leq 12$
Reflections collected/unique	7439/1728 [$R_{int} = 0.0481$]
Completeness to $\theta = 25.02^\circ$	99.9 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.1885 and 0.1688
Refinement method	Full-matrix least-squares on F^2
Data/restraints/parameters	1728/0/175
Goodness-of-fit on F^2	1.064
Final R indices [$I > 2\sigma(I)$]	$R_1 = 0.0317$, $wR_2 = 0.0700$
R indices (all data)	$R_1 = 0.0424$, $wR_2 = 0.0783$
Largest diff. peak and hole	2.731 and -1.239 e Å ⁻³

Fig. 1. Molecular structure of the Eu complex

coordinated by nine O atoms. One oxalic acid molecular bridges two Eu atoms. The Eu-O distances are in the range of 2.414–2.544 Å. The angles of O-Eu-O are in the range of 63.98–143.8°. The torsion angles of O(1)-Eu(1)-O(3)-C(2), O(3)-Eu(1)-O(1)-C(1), O(9)-Eu(1)-O(1)-C(1) are 5.6, 129.1 and 64.0°, respectively. Selected bond lengths and bond angles are shown in Table-2.

TABLE-2
SELECT BOND LENGTHS [Å] AND
ANGLES [°] FOR THE TITLE COMPLEX

Eu(1)-O(5)	2.414(5)	O(7)-Eu(1)-O(3)	95.1(2)
Eu(1)-O(1)	2.423(5)	O(9)-Eu(1)-O(3)	71.84(19)
Eu(1)-O(7)	2.423(6)	O(5)-Eu(1)-O(8)	83.6(2)
Eu(1)-O(9)	2.429(5)	O(1)-Eu(1)-O(8)	81.0(2)
Eu(1)-O(3)	2.464(5)	O(7)-Eu(1)-O(8)	72.3(2)
Eu(1)-O(8)	2.477(6)	O(9)-Eu(1)-O(8)	137.3(2)
N(1)-C(6)	1.11(4)	C(2)-O(3)-Eu(1)	123.1(5)
O(1)-C(1)	1.242(9)	C(3)-O(5)-Eu(1)	121.4(5)
O(2)-C(1)	1.263(9)	O(8)-Eu(1)-O(4)#3	135.9(2)
O(5)-C(3)	1.244(9)	C(1)-O(1)-Eu(1)	121.2(5)
O(6)-C(3)	1.257(9)	C(1)-O(2)-Eu(1)#1	119.2(5)
O(9)-H(9D)	0.8501	C(2)-O(3)-Eu(1)	123.1(5)
O(10)-C(4)	1.42(4)	C(2)-O(4)-Eu(1)#3	120.1(5)
C(4)-H(4A)	0.9700	C(3)-O(5)-Eu(1)	121.4(5)
C(5)-H(5B)	0.9600	C(3)-O(6)-Eu(1)#2	119.2(5)
C(6)-C(7)	1.43(5)	Eu(1)-O(7)-H(7F)	134.6
C(7)-H(7C)	0.9600	Eu(1)-O(7)-H(7G)	116.2
O(5)-Eu(1)-O(1)	137.48(19)	H(7F)-O(7)-H(7G)	108.7
O(5)-Eu(1)-O(7)	137.06(19)	Eu(1)-O(8)-H(8C)	121.1
O(1)-Eu(1)-O(7)	73.71(19)	Eu(1)-O(8)-H(8D)	128.6
O(5)-Eu(1)-O(9)	76.1(2)	H(8C)-O(8)-H(8D)	108.6
O(1)-Eu(1)-O(9)	89.2(2)	Eu(1)-O(9)-H(9C)	118.2
O(7)-Eu(1)-O(9)	143.8(2)	O(5)-C(3)-O(6)	126.7(7)
O(5)-Eu(1)-O(3)	82.76(19)	N(1)-C(6)-C(7)	167(4)
O(1)-Eu(1)-O(3)	130.50(19)	—	—

The molecular structure stabilized by the O-H...O and O-H...N hydrogen-bonding interactions.

ACKNOWLEDGEMENTS

This study were supported by the Natural Science Foundation of Shandong Province (No. ZR2010BL025), Open Project of State Key Laboratory of Supramolecular Structure and Materials (No. sklssm201323)(Jilin University), State Key Laboratory of Inorganic Synthesis and Preparative Chemistry (No. 2011-13) (Jilin University) and the National Science Foundation of China (No. 21171132).

REFERENCES

1. S.K. Ghosh, J.P. Zhang and S. Kitagawa, *Angew. Chem.*, **119**, 8111 (2007).
2. J.W. Han and C.L. Hill, *J. Am. Chem. Soc.*, **129**, 15094 (2007).
3. A. Fratini, G. Richards, E. Larder and S. Swavey, *Inorg. Chem.*, **47**, 1030 (2008).
4. B.D. Chandler, D.T. Cramb and G.K.H. Shimizu, *J. Am. Chem. Soc.*, **128**, 10403 (2006).
5. A. Mondry and P. Starynowicz, *Eur. J. Inorg. Chem.*, **5**, 1859 (2006).
6. J. Wang, P. Hu, B. Liu, R. Xu, X. Wang, D. Wang, L.Q. Zhang and X.D. Zhang, *J. Struct. Chem.*, **52**, 568 (2011).
7. X. Li, D.-Y. Wei, S.-J. Huang and Y.-Q. Zheng, *J. Solid State Chem.*, **182**, 95 (2009).
8. W. Li, X.-L. Wang, X.-Y. Song, L.-C. Li, D.-Z. Liao and Z.-H. Jiang, *J. Mol. Struct.*, **885**, 1 (2008).
9. U.P. Singh, R. Kumar and S. Upreti, *J. Mol. Struct.*, **831**, 97 (2007).
10. X. Li, Z.Y. Zhang, T.T. Zhang and Y.L. Ju, *J. Coord. Chem.*, **60**, 301 (2007).
11. X. Li, T.T. Zhang, Y.L. Ju, C.Y. Wang, Y.Q. Li, L. Zhang and Q. Zhang, *J. Coord. Chem.*, **60**, 2121 (2007).
12. X. Li, Y.L. Ju and Y.Q. Li, *J. Coord. Chem.*, **61**, 692 (2008).
13. X.-S. Wu, Y.-B. Zhang, X. Li and P.-Z. Li, *J. Coord. Chem.*, **62**, 797 (2009).