Synthesis, X-Ray Crystal Structures and Catalytic Epoxidation of Oxidovanadium(V) Complexes with Aroylhydrazone and Ethyl Maltolate Ligands

Dong-Hui Zou,1,* Min Liang2 and Wei Chen2

1 College of Food and Bio-Engineering, Qiqihar University, Qiqihar 161006, P. R. China
2 School of Chemistry and Chemical Engineering, Qiqihar University, Qiqihar 161006, P. R. China
* Corresponding author: E-mail: zoudongh1000@163.com

Received: 11-30-2020

Abstract

Two oxidovanadium(V) complexes, [VOL1L] (1) and [VOL2L] (2) (L = ethyl maltolate), derived from the aroylhydrazones 4-bromo-N’-(2-hydroxy-5-methylbenzylidene)benzohydrazide (H2L1) and N’-(3,5-dibromo-2-hydroxybenzylidene)4-methoxybenzohydrazide (H2L2), respectively, have been synthesized and characterized by elemental analysis, infrared and electronic spectroscopy. Structures of the complexes were further confirmed by single crystal X-ray determination. The V atoms in the complexes are coordinated by the ONO donor atoms of the aroylhydrazone ligand, OO donor atoms of the ethyl maltolate ligand, and one oxido O atom, forming octahedral coordination. The complexes function as effective olefin epoxidation catalysts with hydrogen peroxide as terminal oxidant and sodium hydrogen carbonate as a co-catalyst.

Keywords: Aroylhydrazone; vanadium complex; catalytic activity; crystal structure

1. Introduction

Schiff base complexes have gained remarkable attention due to their interesting applications in the development of new materials like catalysts, and biological applications like DNA cleavage, antibacterial, antiviral and antifungal agents.1 Metal complexes of hydrazone type Schiff bases were used as catalysts for the organic synthesis, such as olefin polymerization and epoxidation reactions.2 Among the various metal ions, the complexes of vanadium have received considerable interest in their biochemical significance and industrial catalytic processes.3 For instance, the use of vanadium complexes in asymmetric synthesis, in C–C bond formation as well as in C–C, C–O and C–H bond cleavages, catalytic oxidation of various olefins, oxidative halogenation and selective epoxidation of unsaturated hydrocarbons and alky alcohols.4 Aroylhydrazones bearing typical –CO–NH–N=CH– group are interesting ligands in the preparation of various metal complexes which have considerable biological and catalytic properties.5 To date, a number of vanadium complexes have been obtained. However, the vanadium complexes with hydrazones are rarely reported with catalytic oxidation of olefins. Recently, our research group has reported some vanadium complexes and their catalytic epoxidation property.6 As a continuation of such work, we report in this paper two new vanadium(V) complexes [VOL1L] (1) and [VOL2L] (2) (L = ethyl maltolate), derived from the aroylhydrazones 4-bromo-N’-(2-hydroxy-5-methylbenzylidene)benzohydrazide (H2L1) and N’-(3,5-dibromo-2-hydroxybenzylidene)4-methoxybenzohydrazide (H2L2).

2. Experimental

2.1. Materials and Methods

5-Methylsalicylaldehyde, 3,5-dibromosalicylaldehyde, 4-bromobenzohydrazide and 4-methoxybenzohydrazide were purchased from Sigma-Aldrich. VO(acac)2 and the solvents with analytical reagent grade were purchased from Xiya Chemicals Co. Ltd. Microanalyses for C, H, N were carried out using a Perkin Elmer 2400 CHNS/O elemental analyzer. 1H NMR spectra were recorded on a Bruker AVANCE 500 MHz spectrometer. FT-IR spectra were recorded on a FT-IR 8400-Shimadzu as KBr discs in
the range of 400–4000 cm\(^{-1}\). UV-Vis spectra were recorded on a Lambda 35 spectrometer. X-ray diffraction data were collected using a Bruker Smart 1000 CCD diffractometer.

### 2. 3. Synthesis of 4-bromo-\(N'-(3,5\text{-dibromo-2-hydroxybenzylidene})\)benzohydrazide (\(\text{H}_2\text{L}^1\))

An ethanolic solution (20 mL) containing 3,5-dibromo-2-hydroxybenzaldehyde (1.0 mmol, 0.28 g) was added dropwise to an ethanolic solution of 4-bromobenzohydrazide (1.0 mmol, 0.17 g) with constant stirring. The mixture was refluxed for 30 min, after which the solvent was removed by rotary evaporator. The white precipitate was collected using a Bruker SMART 1000 CCD diffractometer.

| Parameters | 1 | 2 |
|------------|---|---|
| Molecular formula | \(\text{C}_{22}\text{H}_{18}\text{BrN}_{2}\text{O}_{6}\text{V}\) | \(\text{C}_{22}\text{H}_{17}\text{Br}_{2}\text{N}_{2}\text{O}_{7}\text{V}\) |
| Formula weight | 632.13 | 632.13 |
| Crystal system | Triclinic | Triclinic |
| Space group | \(P\bar{1}\) | \(P\bar{1}\) |
| \(a\) (Å) | 7.4116(9) | 7.4116(9) |
| \(b\) (Å) | 11.8466(11) | 11.8466(11) |
| \(c\) (Å) | 13.2718(12) | 13.2718(12) |
| \(\alpha\) (°) | 90.253(1) | 90.253(1) |
| \(\beta\) (°) | 88.952(1) | 88.952(1) |
| \(\gamma\) (°) | 93.496(1) | 93.496(1) |
| \(V\) (Å\(^3\)) | 1108.8(2) | 1108.8(2) |
| \(Z\) | 2 | 2 |
| \(D_{calc}\) (g/cm\(^3\)) | 1.690 | 1.690 |
| \(\mu\) (mm\(^{-1}\)) | 2.980 | 2.980 |
| \(F(000)\) | 540 | 540 |
| Reflections collected | 5921 | 5921 |
| Independent reflection (\(R_{int}\)) | 4075 (0.0134) | 4312 (0.0405) |
| Reflections observed (\(I>2\sigma(I)\)) | 3102 | 3227 |
| Data/restraints/parameters | 4075/0/291 | 4312/0/309 |
| Goodness-of-fit on \(F^2\) | 1.025 | 1.049 |
| Final \(R\) indices (\(I>2\sigma(I)\)) | 0.0537, 0.1333, 0.0399, 0.0829 | 0.0537, 0.1333, 0.0399, 0.0829 |
| \(R\) indices (all data) | 0.0740, 0.1465, 0.0644, 0.0926 | 0.0740, 0.1465, 0.0644, 0.0926 |
| Max/min \(Dp\) (e Å\(^{-3}\)) | 1.034, –1.007 | 0.530, –0.449 |

2. 4. Synthesis of the complexes \([\text{VOL}_1\text{L}]\) (1) and \([\text{VOL}_2\text{L}]\) (2)

The aroylhydrazones \(\text{H}_2\text{L}^1\) (0.10 mmol, 33 mg) or \(\text{H}_2\text{L}^2\) (0.10 mmol, 43 mg) was dissolved in ethanol (15 mL). To each solution an ethanolic solution of \(\text{VO(acac)}_2\) (0.10 mmol, 26 mg) and ethyl maltol (0.1 mmol, 14 mg) was added with stirring. Mixtures were stirred at room temperature for 30 min to give deep brown solution. Brown block-shaped single crystals suitable for X-ray analysis were obtained after slow evaporation of the solvent over a few days. The crystals were isolated by filtration.

Complex 1: Yield: 0.18 g, 33%. For \(\text{C}_{22}\text{H}_{18}\text{BrN}_{2}\text{O}_{6}\text{V}\): anal. calcd., %: C, 49.18; H, 3.38; N, 5.21. Found, %: C, 49.35; H, 3.31; N, 5.12. FT-IR (KBr), cm\(^{-1}\): \(ν(\text{C}=\text{N}) 1611, ν(\text{C}–\text{O}) 1176, ν(\text{V}=\text{O}) 971\). UV-Vis data in ethanol (λ nm (ε, M\(^{-1}\)cm\(^{-1}\))): 217 (18,223), 325 (10,370), 410 (2,738).

Complex 2: Yield: 0.26 g, 41%. For \(\text{C}_{22}\text{H}_{17}\text{Br}_{2}\text{N}_{2}\text{O}_{7}\text{V}\): anal. calcd., %: C, 41.80; H, 2.71; N, 4.43. Found, %: C, 41.61; H, 2.83; N, 4.51. FT-IR (KBr), cm\(^{-1}\): \(ν(\text{C}=\text{N}) 1608, ν(\text{C}–\text{O}) 1173, ν(\text{V}=\text{O}) 972\). UV-Vis data in ethanol (λ nm (ε, M\(^{-1}\)cm\(^{-1}\))): 265 (19,560), 332 (12,451), 413 (3,890).

2. 5. X-Ray Structure Determination

Crystal structures of complexes were measured on a Bruker SMART 1000 CCD diffractometer using Mo-K\(^{α}\) radiation (λ = 0.71073 Å) and a graphite monochromator at 25 °C. Unit cell and reflection data were obtained by standard methods and are summarized in Table 1.7 The structures were solved, refined, and prepared for publication using the SHIELT package (structure solution refinement and molecular graphics), and using full-matrix least-squares techniques by using \(F^2\) with anisotropic displacement factors for all non-hydrogen atoms. The amino H atoms were located from difference Fourier maps and

---

Zou et al.: Synthesis, X-Ray Crystal Structures and Catalytic...

Acta Chim. Slov. 2021, 68, 441–446
refined isotropically, with N–H distances restrained to 0.90(1) Å. Positions of the remaining hydrogen atoms were calculated from the structure of the molecular skeleton and their displacement parameters were refined isotropically on a group-wise basis.

3. Results and Discussion

3.1. Synthesis and Spectral Characterization

The two complexes were readily prepared from the reaction of the corresponding aroylhydrazone ligands and VO(acac)₂. The single crystals of the complexes are stable at ambient condition.

The ν(C=N) absorptions are observed at 1611 cm⁻¹ for 1 and 1608 cm⁻¹ for 2. The intense bands indicative of the C=O vibrations and the sharp bands indicative of the N–H vibrations are absent in the complexes, indicating the enolization of the aroylhydrazone ligands. The weak peaks in the low wave numbers in the region 450–700 cm⁻¹ may be attributed to V–O and V–N bonds in the complexes. The complexes exhibit typical bands at 971–972 cm⁻¹, which are assigned to the V = O vibrations.

The UV-Vis spectra of the complexes were recorded in 10⁻⁵ mol L⁻¹ in ethanol, in the range 200–500 nm. The weak bands centered at 325–332 nm for the complexes are attributed to intramolecular charge transfer transitions from the pπ orbital on the nitrogen and oxygen to the empty d orbitals of the metal. The intense bands observed at 265–270 nm are assigned to intraligand π–π* transition. The bands centered at about 410 nm are attributed to the ligand-to-metal charge transfer transitions (LMCT).

3.2. Structure Description of the Complexes

The molecular structures of complexes 1 and 2 are shown in Figs. 1 and 2, respectively. Selected bond lengths and angles are reported in Table 2. The V atoms in both complexes are six-coordinated in octahedral geometry, with the phenolate oxygen (O(1)), the enolate oxygen (O(2)) and the imine nitrogen (N(1)) of the aroylhyclzone ligands, and the hydroxylate oxygen (O(5)) of the ethyl maltolate ligand in the equatorial plane, and with the oxido group (O(3)) and the carbonyl oxygen (O(4)) in the axial positions. The V atoms deviated from the least-squares planes defining by the four equatorial donor at-
oms by 0.295(2) Å for 1 and 0.290(2) Å for 2. The bond lengths related to the V atoms are comparable to the similar vanadium complexes.6b,12 The benzene rings C(1)–C(6) and C(9)–C(14) form dihedral angles of 2.1(3)° for 1 and 2.7(3)° for 2. There exists weak Br(1)···O(7)i (i: –1 + x, y, 1 + z) contact with distance of 2.96(5) Å representing 87.8 % of the sum of van der Waals radii in complex 2.

In the crystal structure of complex 1, the vanadium complex molecules are linked through C−H∙∙∙O hydrogen bonds (Table 3) to form layers along the ab plane (Fig. 3). In the crystal structure of complex 2, the vanadium complex molecules are linked through C−H∙∙∙O and C−H∙∙∙Br hydrogen bonds (Table 3) to form three-dimensional network (Fig. 4).

### Table 2. Selected bond lengths (Å) and angles (°) for the complexes

| Bond lengths (Å) | 1          | 2          |
|------------------|------------|------------|
| V(1)−O(1)        | 1.841(3)   | 1.847(2)   |
| V(1)−O(3)        | 1.580(3)   | 1.583(3)   |
| V(1)−O(5)        | 1.871(3)   | 1.863(2)   |
| V(1)−O(2)        | 1.941(3)   | 1.921(2)   |
| V(1)−O(4)        | 2.261(3)   | 2.259(3)   |
| V(1)−N(1)        | 2.097(3)   | 2.090(3)   |

| Bond angles (°)  | 1          | 2          |
|------------------|------------|------------|
| O(3)−V(1)−O(1)   | 100.96(19) | 99.93(13)  |
| O(1)−V(1)−O(5)   | 98.68(13)  | 100.77(11) |
| O(1)−V(1)−O(2)   | 155.11(14) | 154.62(11) |
| O(3)−V(1)−N(1)   | 101.16(14) | 99.60(13)  |
| O(5)−V(1)−N(1)   | 160.03(12) | 160.64(12) |
| O(3)−V(1)−O(4)   | 173.29(17) | 175.04(13) |
| O(5)−V(1)−O(4)   | 77.53(10)  | 77.60(10)  |
| N(1)−V(1)−O(4)   | 82.89(11)  | 84.41(11)  |
| O(3)−V(1)−O(5)   | 97.98(14)  | 98.05(12)  |
| O(3)−V(1)−O(2)   | 95.33(17)  | 97.23(12)  |
| O(5)−V(1)−O(2)   | 97.53(12)  | 95.16(10)  |
| O(1)−V(1)−N(1)   | 83.29(13)  | 83.99(11)  |
| O(2)−V(1)−N(1)   | 75.14(12)  | 74.78(11)  |
| O(1)−V(1)−O(4)   | 84.75(14)  | 83.34(11)  |
| O(2)−V(1)−O(4)   | 80.45(12)  | 80.93(11)  |

### Table 3. Hydrogen bonding interactions (Å, °)

| D−H···A          | d(D−H)  | d(H···A) | d(D···A) | Angle(D−H···A) |
|------------------|---------|---------|---------|---------------|
| 1                |         |         |         |               |
| C(6)−H(6)−O(3)ii | 0.93    | 2.50(3) | 3.367(5)| 154(6)        |
| C(7)−H(7)−O(3)iii| 0.93    | 2.53(3) | 3.143(5)| 124(6)        |
| C(14)−H(14)−O(6)iv| 0.93  | 2.57(3) | 3.399(5)| 148(6)        |
| C(21)−H(21)−O(4)v | 0.93 | 2.42(3) | 3.246(5)| 148(6)        |
| 2                |         |         |         |               |
| C(6)−H(6)−O(3)vi | 0.93    | 2.56(3) | 3.237(4)| 130(5)        |
| C(11)−H(11)−Br(2)vii| 0.93 | 2.80(3) | 3.563(4)| 140(5)        |
| C(19)−H(19)−O(7)viii| 0.93 | 2.47(3) | 3.340(4)| 156(5)        |

Symmetry codes: ii) 1 + x, y, z; iii) 1 − x, 1 − y, 1 − z; (iv) −x, −y, −z; (v) 1 − x, −y, 1 − z; (vi) −x, 1 − y, 1 − z; (vii) 1 + x, −1 + y, z; (viii) −x, −y, 1 + z.

### 3.3. Catalytic Property

The catalytic experiment was carried out according to the literature method.6 A mixture of CH₃OH/CH₂Cl₂ (V:V = 7:3, 1.2 mL) was used for the reactions at 25 °C. The molar ratios for the catalyst:substrate:NaHCO₃:H₂O₂ are 1:298:117:1170. The conversion was measured after 74.5 min. Both vanadium complexes have good property in the olefin oxidation processes with epoxides as the products. The results are summarized in Table 4. Interestingly, both complexes have similar catalytic properties with high epoxide yields and good selectivity toward the aliphatic and aromatic substrates. However, when H₂O₂ was used as single oxidant the catalytic efficiency is not good. When NaHCO₃ was added as a co-catalyst to the above reactions,
the efficiency of the catalytic property can increase obviously. This might be attributed to the equilibrium process between H$_2$O$_2$ and hydrogen carbonate to produce peroxymonocarbonate, HCO$_3^-$, which is a more reactive nucleophile than H$_2$O$_2$ and facilitated the epoxidation reactions. The two vanadium complexes have better catalytic properties than the cobalt(II) complex derived from 2-bromo-N’-(2-hydroxy-5-methylbenzylidene)benzohydrazide, and similar catalytic properties with the oxido-group. The complexes show effective catalytic properties in the oxidation of various olefins to their correspond-

### 4. Conclusion

Two new similar oxidovanadium(V) complexes with aroylhydrazone ligands have been prepared and structurally characterized using X-ray structure analysis. The complexes have octahedral geometry with positions around the central atom being occupied with donor atoms of the aroylhydrazone ligand, the ethyl maltolate ligand and one oxido group. The complexes show effective catalytic property in the oxidation of various olefins to their corresponding epoxides.

### Supplementary Material

CCDC reference numbers 2043121 and 2043122 contain the supplementary crystallographic data for this article. These data can be obtained free of charge at: http://www.ccdc.cam.ac.uk, or from Cambridge Crystallographic Data Center, 12 Union Road, Cambridge CB2 1EZ, UK; Fax: +44 1223 336 033; Email: deposit@ccdc.cam.ac.uk.

### Acknowledgments

This work was financially supported by the Fundamental Research Funds in Heilongjiang Provincial Universities (Project No. 135409307).

### 5. References

1. (a) H. Zakeri, S. Rayati, G. Zarei, A. Parsa, F. Adhami, *Iran. J. Catal.* 2020, 10, 71–78; (b) M. Gillard, J. Weynand, H. Bonnet, F. Loiseau, A. Decottignies, J. M. Dejeu, E. Defrancq, B. Elias, *Chem. Eur. J.* 2020, 26, 13849–13860; DOI:10.1002/chem.202001409
2. (a) A. Arunadevi, N. Raman, *J. Coord. Chem.* 2020, 73, 2095–2116; DOI:10.1080/00958972.2020.1824293
3. (a) M. Galvan-Hidalgo, D. M. Roldan-Marchan, A. Gonzalez-Hernandez, T. Ramirez-Apan, A. Nieto-Camacho, S. Hernandez-Ortega, E. Gomez, *Med. Chem. Res.* 2020, 29, 2146–2156; DOI:10.1007/s00044-020-02630-4
4. (a) S. Kumari, S. Ray, *New J. Chem.* 2020, 44, 14953–14963; DOI:10.1039/D0NJ01590C
5. (a) S. Q. T. Pham, C. Richardson, C. Kelso, A. C. Willis, S. F. Ralph, *Dalton Trans.* 2020, 49, 10360–10379; DOI:10.1039/D0DT01370F
6. (a) R. Ramachandran, G. Prakash, P. Viswanathamurthi, J. G. Malecki, *Inorg. Chem. Acta* 2018, 477, 122–129; DOI:10.1016/j.ica.2018.03.007
7. (a) M. Ghorbanloo, A. M. Alamooti, *J. Porous Mater.* 2017, 24, 769–777; DOI:10.1007/s10934-016-0314-9
8. (a) S. Selvamurugan, R. Ramachandran, G. Prakash, P. Viswanathamurthi, J. G. Malecki, A. Endo, *J. Organomet. Chem.* 2016, 803, 119–127; DOI:10.1016/jorganchem.2015.11.017
9. (a) D. Muthumari, R. Ramesh, *RSC Advances* 2016, 6, 52101–52112; DOI:10.1039/C6RA06734D
10. (a) Y.-J. Cai, Y.-Y. Wu, F. Pan, Q.-A. Peng, Y.-M. Cui, *Acta Chim. Slov.* 2020, 67, 896–903; DOI:10.17344/acs.2020.5895
11. (a) S. Ashkhademi, N. Noshiranadezeh, M. S. Sadjadi, K. Mehrani, N. Farhadyar, *Polyhedron* 2019, 160, 115–122; DOI:10.1016/j.poly.2018.12.023
12. (a) J. Szklarzewicz, A. Jurawska, M. Hodorowicz, R. Grybos, K. Kruczala, M. Gluch–Lutwin, G. Kazek, *J. Coord. Chem.* 2020, 73, 986–1008; (b) L.-P. Lu, F.-Z. Suo, Y.-L. Feng, L.-L. Song, Y. Li, Y.-J. Li, K.-T. Wang, *Eur. J. Med. Chem.* 2019, 176, 1–10; (c) F. Heidari, S. J. A. Fatemi, S. Y. Ebrahimipour, H. Ebrahimejad, J. Castro, M. Dusek, V. Eigner, *Inorg. Chem. Commun.* 2017, 76, 1–4; (d) M. Sutradhar, L. M. D. R. S. Martins, M. F. C. Guedes da Silva, A. J. L. Pombeiro, *Coord. Chem. Rev.* 2015, 301–302, 200–239.
13. (a) L. Schober, M. Sako, S. Takizawa, H. Groger, H. Sasai, *Chem. Commun.* 2020, 56, 10151–10154; DOI:10.1039/D0CC02621B
14. (a) S. Kumari, S. Ray, *New J. Chem.* 2020, 44, 14953–14963; DOI:10.1039/D0NJ01590C
15. (a) Y. Sekiguchi, K. Arashiba, H. Tanaka, A. Eizawa, K. Na-

### Table 4. The catalytic oxidation results

| Substrate | Product | Conversion (%) (TON)* |
|-----------|--------|-----------------------|
| 1         |        | > 99 (351)            |
| 2         |        | > 99 (367)            |
| 1         |        | 98 (343)              |
| 2         |        | > 99 (327)            |
| 1         |        | 93 (310)              |
| 2         |        | 96 (307)              |
| 1         |        | 95 (282)              |
| 2         |        | 97 (291)              |

*TON = (mmol of product)/mmol of catalyst.
kajima, K. Yoshizawa, Y. Nishibayashi, Angew. Chem. Int. Ed. 2018, 57, 9064–9068; DOI:10.1002/anie.201802310
(d) M. R. Maurya, N. Jangra, F. Avecilla, I. Correia, Eur. J. Inorg. Chem. 2019, 2, 314–329; DOI:10.1002/ejc.201801243
(e) J. C. Pessoa, M. R. Maurya, Inorg. Chim. Acta 2017, 455, 415–428. DOI:10.1016/j.jica.2016.04.012
5. (a) D. Sadhukhan, A. Ray, G. Pilet, C. Rizzoli, G. M. Rosair, C. J. Gomez-Garcia, S. Signorella, S. Bellu, S. Mitra, Inorg. Chem. 2011, 50, 8326–8339; DOI:10.1021/ic200846j
(b) M. Bagherzadeh, M. Zare, T. Salmennoush, S. Oskar, S. Akbayrak, Appl. Catal. A-General 2014, 475, 55–62; DOI:10.1016/j.apcata.2014.01.020
(c) V. Vrdoljak, J. Pisk, D. Agustin, P. Novak, J. P. Vukovic, D. Matkovic-Calogovic, New J. Chem. 2014, 38, 6176–6185; DOI:10.1039/C4NJ01394H
(d) M. Ghorbanlou, R. Bikas, G. Malecki, P. Kajim, K. Yoshimura, Y. Nishibayashi, Acc. Chem. Res. 2016, 49, 670–677; DOI:10.1021/acs.accounts.5b00323
(e) Z. Moradi-Shoeili, M. Zare, S. Akbayrak, S. Oskar, Transition Met. Chem. 2017, 42, 357–363; DOI:10.1007/s11243-017-0139-7
6. (a) D.-H. Zou, N. Sun, W. Chen, J. Struct. Chem. 2019, 60, 1101–1109; DOI:10.1134/S0022476619070114
(b) M. Liang, D.-H. Zou, Acta Chim. Slov. 2016, 63, 180–185; DOI:10.17344/acsi.2015.2169
(c) M. Liang, D.-H. Zou, Inorg. Nano-Met. Chem. 2017, 47, 110–115; DOI:10.1080/15533174.2016.1194730
(d) M. Liang, N. Sun, D.-H. Zou, Acta Chim. Slov. 2018, 65, 964–969; DOI:10.17344/acs.2018.4625
7. Bruker, SMART (Version 5.264) and SAINT (Version 6.04) programs using the windows NT system, Bruker AXS Inc., Madison, WI, USA, 2001.
8. G. M. Sheldrick, Acta Crystallogr. 2008, A64, 112–122. DOI:10.1107/S0108767307043930
9. D. Sadhukhan, M. Maiti, E. Zangandro, S. Pathan, S. Mitra, A. Patel, Polyhedron 2014, 69, 1–9. DOI:10.1016/j.poly.2013.11.007
10. A. Sarkar, S. Pal, Polyhedron 2006, 25, 1689–1694. DOI:10.1016/j.poly.2005.11.009
11. S. Roy, T. N. Mandal, K. Das, R. J. Butcher, A. L. Rheingold, S. K. Kar, J. Coord. Chem. 2010, 63, 2146–2157. DOI:10.1080/00958972.2010.499457
12. (a) J.-X. Lei, J. Wang, Y. Huo, Z. You, Acta Chim. Slov. 2016, 63, 670–677; (b) L. Xu, Y. Li, M. Duan, Y. Li, M. Han, J. Wu, Y. Wang, K. Dong, Z. You, Polyhedron 2019, 165, 138–142; DOI:10.1016/j.poly.2019.03.016
(c) Q.-C. Zhou, T.-R. Wang, H. Li, L. Chen, J.-J. Xin, S. Guo, G.-H. Sheng, Z.-L. You, J. Inorg. Biochem. 2019, 196, 110680; DOI:10.1016/j.jinorgbio.2019.03.020
(d) Z.-Q. Sun, S.-F. Yu, X.-L. Xu, X.-Y. Qiu, Acta Chim. Slov. 2020, 67, 1281–1289; DOI:10.17344/acsi.2020.6236
(e) D. L. Peng, Russ. J. Coord. Chem. 2020, 46, 276–282; DOI:10.1134/S1070328420040065
(f) L. Li, K.-W. Lu, Y.-T. Li, G.-F. Jiang, Y. Xin, L. Ye, Y. Zhang, H. Liu, C.-N. Shang, Z.-L. You, Chin. J. Inorg. Chem. 2017, 33, 905–912; DOI:10.1007/s04242-017-7240-5
(g) Y. M. Cui, Y. Q. Wang, X. X. Su, H. Huan, P. Zhang, J. Struct. Chem. 2019, 60, 1299–1305. DOI:10.1134/S0022476619080092
13. F.-M. Wang, Acta Chim. Slov. 2016, 63, 406–410. DOI:10.1109/TCSII.2015.2505038
14. (a) H.-Y. Liu, Y.-S. Yin, L.-J. Yang, X.-L. Zhou, Y.-F. Ye, Acta Chim. Slov. 2020, 67, 130–136; DOI:10.17344/acs.2019.5286
(b) Q.-A. Peng, X.-P. Tan, Y.-D. Wang, S.-H. Wang, Y.-X. Jiang, Y.-M. Cui, Acta Chim. Slov. 2020, 67, 644–650; DOI:10.17344/acs.2019.5650
(c) Q. Yang, P. Wang, Y. Lei, Acta Chim. Slov. 2020, 67, 927–933; DOI:10.17344/acs.2020.5932
(d) M. Abdi, A. F. Shojaei, M. Ghadermazi, Z. Moradi-Shoeili, Acta Chim. Slov. 2020, 67, 476–486. DOI:10.17344/acs.2019.5466

Povzetek
Sintetizirali smo dva oksidovanadijeva(V) kompleksa, [VOL1L] (1) in [VOL2L] (2) (L = etil maltolat), pripravljena z aroilhidrazonoma 4-bromo-N'-(2-hidroksi-5-metilbenzilenid)benzohidrazidom (H3L1) in N'-(3,5-dibromo-2-hidroksibenzilenid)–4-metoksibenzohidrazidom (H3L2) ter ju okarakterizirali z elementno analizo, infrardečo in elektronsko spektroskopijo. Strukturi kompleksov smo nadalje potrdili z monokristalno rentgensko difrakcijo. Vanadijev atom v obeh kompleksih je koordiniran z ONO donorskimi atomi aroilhidrazonskega liganda, OO donorskimi atomi etil maltolatnega liganda in z enim oksido O atomom, ki skupaj tvorijo oktaedrično koordinacijo. Kompleksa sta učinkovita katalizatorja za epoksicacijo olenin z vodikovim peroksidom kot oksidantom in natrijevim hidrogenkarbonatom kot kokatalizatorjem.