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## IR SPECTRA OF DIMOLYBDENUM TETRA- $\mu_2$ -PHENYLACETATE COMPLEX AND ITS DERIVATIVES

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**Abstract:** The study describes the synthesis, thermal and spectral characteristics of tetra- $\mu_2$ -phenylacetate complex of dimolybdenum –  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$  and its derivatives in the type  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  [where  $\text{L}' = \alpha$ -,  $\beta$ -picoline ( $\alpha$ -,  $\beta$ -Pic), 4-vinylpyridine (4-VinPy), quinoline (Q)]. The comparison of IR spectra of the synthesized  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  complexes with the spectra of liquid  $\text{L}'$  ligands reveals their great similarity. Nearly every band in the IR spectra of the free  $\text{L}'$  ligands is reproduced in the spectra of the complex with a slight long-wavelength shift or splitting, which is a consequence of the coordination of  $\text{L}'$  through the nitrogen heteroatom. However, when comparing the shift values of the stretching vibration frequencies  $\nu_{(\text{ring})}$ , non-planar and planar bending vibrations of the C-H and C-C bonds of heterocyclic rings, as well as the values of bending vibrations of the frequencies  $\delta(\text{CCC})$ ,  $\delta(\text{CNC})$  in the spectra of the  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  complexes and the previously obtained  $[\text{Mo}_2(\text{O}_2\text{CH})_4]\text{L}''_2$  complex [1] [where,  $\text{L}'$  and  $\text{L}'' = \alpha$ -,  $\beta$ -Pic, 4-VinPy, Q], it turns out that the coordination bonds of Mo-L' in axial positions in these adducts are weak. It also revealed that when heating adducts with the composition  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$ , the  $\text{L}'$  ligands are completely removed at 70-100 °C. After heating of each sample at the appropriate temperature for 2 hours (Table 3), their IR spectra completely coincided with the spectra of the original dimolybdenum tetra- $\mu_2$ -phenylacetate complex.

**Key words:** phenylacetate, dimolybdenum,  $\alpha$ - and  $\beta$ -picoline, stretching and bending vibrations, thermolysis  
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### Introduction

As is shown in [1], the complexes like  $\alpha$ -hydroxyphenylacetatodimolybdenum  $[\text{Mo}_2(\text{O}_2\text{CCH}(\text{OH})\text{C}_6\text{H}_5)_4]\text{L}_2$  (L is a molecule of an organic base) cannot be synthesized, apparently due to steric hindrances created by the hydroxo group located in the  $\alpha$ -position relative to COO group in the mandelic acid

molecule. Replacing the hydroxo group of mandelic acid with a hydrogen atom, for example, in a phenylacetic acid molecule, should eliminate these obstacles. Therefore, in this study, we have carried out the synthesis of complexes of molybdenum (II) with phenylacetic acid.

### Materials and methods

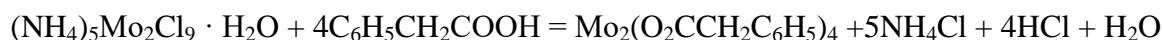
**Synthesis of tetra- $\mu_2$ -phenylacetatodimolybdenum  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$ .** 1 g of phenylacetic acid  $\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$  is dissolved in 30 ml of distilled water on heating (at about 80 °C). The resulting solution is cooled to room temperature

and 1.13 g of ammonium nonachlorodimolybdate (II) hydrate  $(\text{NH}_4)_5\text{Mo}_2\text{Cl}_9 \cdot \text{H}_2\text{O}$  is added in portions. The mixture is stirred for 5 minutes. The resulting light-yellow crystalline substance is filtered off, washed several times with absolute ethyl

alcohol and dried in vacuum at room temperature. The elemental analysis of the sample of the resulting substance is compliant with the composition  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$ .

Found: Mo–26.8%; C–53.0%; H–4.0%  
Calculated: Mo–26.2%; C–52.4%; H–3.8%

The synthesis given in the method is described by the following reaction equation:

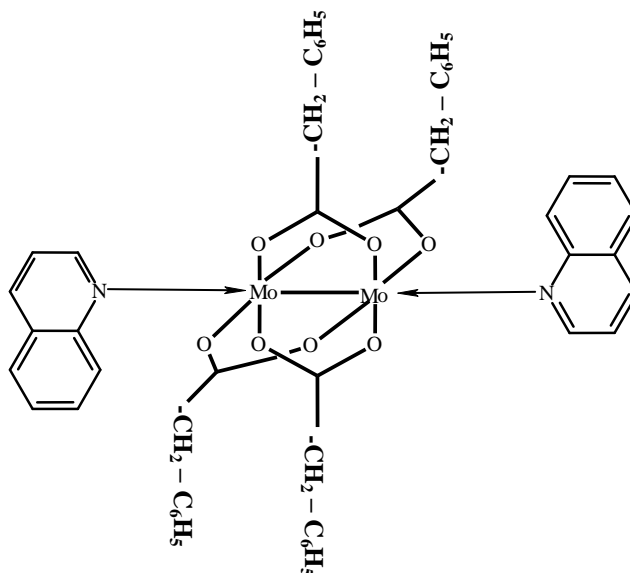


**Synthesis of tetra- $\mu_2$ -phenylacetatodimolybdenum diquinoline**  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4](\text{C}_9\text{H}_7\text{N})_2$ . 0.5 g of tetra- $\mu_2$ -phenylacetatodimolybdenum in 15–20 ml of quinoline (Q) is heated at about 90 °C in a flask under reflux in a flow of argon until complete dissolution of initial complex. The resulting yellow-brown solution is cooled in an argon atmosphere to room temperature. The precipitated orange-yellow crystals in the form

of quadrangular prisms are filtered, washed with absolute ethyl alcohol and dried in vacuum. Elemental analysis of a sample of the resulting substance corresponds to the composition  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4](\text{C}_9\text{H}_7\text{N})_2$ :

Found: Mo–20.0%; C–61.0%; H–4.4%; N–2.9%  
Calculated: Mo–19.4%; C–60.6%; H–4.2%; N–3.0%

The scheme shows the structure of the synthesized compound:



Using a similar procedure, derivatives with  $\alpha$ -,  $\beta$ -picoline and 4-vinylpyridine were synthesized from  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$ .

All synthesized compounds  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  ( $\text{L}' = \text{Q}, \alpha\text{-Pic}, \beta\text{-Pic}, 4\text{-VinPy}$ ) are diamagnetic, practically insoluble in water and alcohol, and resistant to moisture and

air oxygen.

IR absorption spectra in the region 400–4000  $\text{cm}^{-1}$  were recorded on a UR-20 spectrophotometer, in the region 200–500  $\text{cm}^{-1}$  on an IKS-22V spectrometer. Samples were prepared by rubbing the substance with vaseline oil or hexachlorobutadiene.

## Results and discussion

In the IR spectrum of crystalline phenylacetic acid, two intense absorption bands with maxima at 1720 and 1420  $\text{cm}^{-1}$  are observed in the region of antisymmetric and symmetric stretching vibrations of the COO group (Table 1, Fig. 1). In coordination of the

acid anion with a molybdenum atom, these frequencies shift to 1510 and 1412  $\text{cm}^{-1}$ , respectively, which is typical for carboxylate groups with aligned COO bonds [2]. The absorption bands of the phenyl ring, located in the regions 1610–1580 and 1550–1460  $\text{cm}^{-1}$ , do

not practically change their position during the formation of the complex.

The absorption band at  $1192\text{ cm}^{-1}$ , observed in the spectrum of  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$ , by analogy with [3], we assigned to the stretching vibration of the Ph-C bond.

In the long-wave region of the IR spectrum of  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$ , three absorption bands of medium intensity were found at  $384$ ,  $324$  and  $290\text{ cm}^{-1}$  (Fig. 2). The bands at  $384$  and  $324\text{ cm}^{-1}$ , according to [4], are attributed, respectively, to antisymmetric and symmetric stretching vibrations of the Mo-O bond, and the absorption band at  $290\text{ cm}^{-1}$  is presumably to the bending vibration of the MoOO group.

Fig. 1 and 2 present the IR spectra of the complex compounds we synthesized with the composition  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  ( $\text{L}' = \text{Q}, \alpha\text{-}, \beta\text{-Pic}, 4\text{-VinPy}$ ), and tables 1 and 2 show some vibrational frequencies observed in these IR spectra.

As is known [5-11], the nature of the coordination of heterocyclic amines can be

judged on the basis of an analysis of the stretching vibrations of the ring, non-planar and planar bending vibrations of the C-H and C-C ring bonds, as well as bending vibrations of CCC- and CNC- groups.

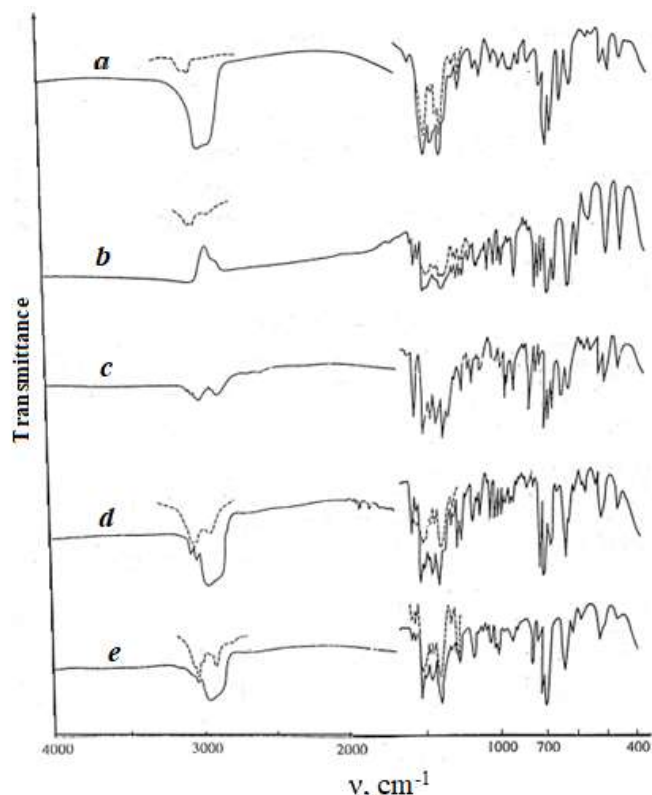
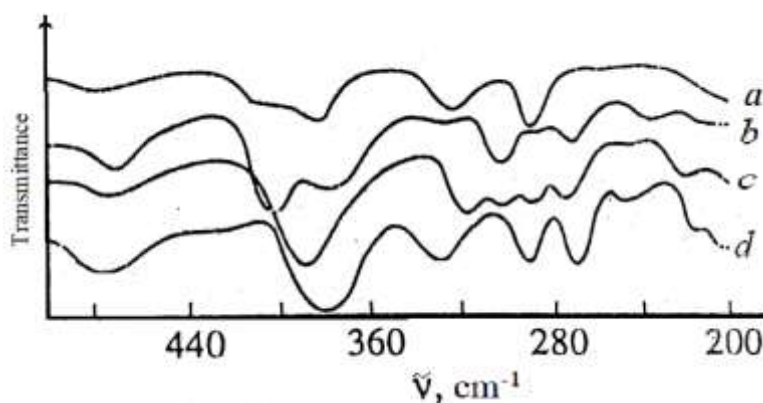
The comparison of the IR spectra of the  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  complexes (where  $\text{L}' = \alpha\text{-}, \beta\text{-Pic}, 4\text{-VinPy}, \text{Q}$ ) with the spectra of the appropriate liquid ligands shows that almost every absorption band in the spectrum of free ligands is reproduced in the spectrum of the complex with a slight shift or splitting, which is a consequence of the coordination of ligands  $\text{L}'$  through the nitrogen atom of the pyridine ring. At the same time, when comparing the shift of characteristic absorption bands in the spectra of phenylacetate  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  and formate  $[\text{Mo}_2(\text{O}_2\text{CH})_4]\text{L}'_2$  complexes, it can be noted that in the case of  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  the changes in the appropriate frequencies are smaller and, therefore, the Mo-N interaction is weaker, than in the case of formate complexes  $[\text{Mo}_2(\text{O}_2\text{CH})_4]\text{L}'_2$ .

**Table 1.** Vibrational frequencies ( $\text{cm}^{-1}$ ) in the IR spectra of phenylacetic acid and dimolybdenum tetra- $\mu_2$ -phenylacetate and their assignment

Assignment	$\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$	$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$
Ring vibrations	1612, 1582	1610, 1580
$\nu_{\text{as}}(\text{COO})$	1720	1510
$\delta_{\text{as}}(\text{CH}_2), \nu(\text{CC})_{\text{rings}}$	1470, 1440	1462, 1438
$\nu_{\text{s}}(\text{COO})$	1420	1412
$\delta_{\text{s}}(\text{CH}_2), \nu(\text{CC})_{\text{rings}}$	1340	1335
$\nu(\text{CC})_{\text{rings}}, \beta(\text{CH})$	1298, 1250	1298, 1285
$\nu(\text{Ph-C})$	1196	1192
$\rho(\text{CH}), \rho(\text{CH}_2)$	1165, 1080, 1032	1165, 1100, 1085
$\nu(\text{CH}_2\text{-C})$	930	1050, 1038, 952, 93
$\gamma(\text{CC})$	870	880
$\gamma(\text{CC}), \rho(\text{CH})$	885, 845, 685	850, 772, 703, 675
$\delta(\text{COO})$	710	730
$\delta(\text{COC})$	607, 615	645, 624
$\gamma(\text{CH})$	476	482
$\nu_{\text{as}}(\text{MoO})$		384
$\nu_{\text{s}}(\text{MoO})$		324
$\delta(\text{MoOO})$		290

**Table 2.** Some vibrational frequencies ( $\text{cm}^{-1}$ ) found in the IR spectra of free and coordinated phenylacetic acid and dimolybdenum complexes and their assignment

Compound	$\nu_{\text{as}}(\text{COO})$	$\nu_{\text{s}}(\text{COO})$	$\Delta\nu(\text{COO})$	$\nu_{\text{as}}(\text{MoO})$	$\nu_{\text{s}}(\text{MoO})$	$\delta(\text{MoOO})$	$\nu(\text{MoN})$
$\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$	1720	1420	300				
$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$	1510	1412	98	384	324	290	
$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4\text{Q}_2$	1525	1410	115	360	320	305	280
$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4(\alpha\text{-Pic})_2$	1534	1420	114	370, 368	330	308	273
$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4(\beta\text{-Pic})_2$	1530	1408	112	312	320	305	275
$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4(4\text{-VinPy})_2$	1532	1404	127	380	332	293	272

**Fig. 1.** IR absorption spectra of  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$  (a),  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{Q}_2$  (b),  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4](4\text{-VinPy})_2$  (c),  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4](\alpha\text{-Pic})_2$  (d),  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4](\beta\text{-Pic})_2$  (e) in vaseline oil, dotted line - in hexachlorobutadiene.**Fig. 2.** Long-wave IR absorption spectra of  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$  (a),  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4](\alpha\text{-Pic})_2$  (b),  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4](\beta\text{-Pic})_2$  (c),  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4](4\text{-VinPy})_2$  (d) in vaseline oil.

Data on thermal stability of phenylacetate  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  and formate  $[\text{Mo}_2(\text{O}_2\text{CH})_4]\text{L}''_2$  complexes are compliant with the results of IR spectroscopy. The behavior of these complexes by heating was studied in the temperature range 25-200 °C in an inert environment (Table 3).

It found that at a temperatures from 70° C to 100° C, complete removal of ligand (L') molecules  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  occurs. The IR spectra of samples heated to the appropriate temperature (Table 3) and kept in a given mode for 2 hours (2 h.) are completely identical to the IR spectra of the  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$  complex.

**Table 3.** Results of thermal studies of phenylacetate  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  and formate  $[\text{Mo}_2(\text{O}_2\text{CH})_4]\text{L}''_2$  complexes [where, L' and L'' =  $\alpha$ -,  $\beta$ -Pic, 4-VinP<sub>y</sub>, Q]

Compound	Ligand removal temperature, °C	Mass loss ( $\Delta m$ ) upon removal of the axial ligand, (found/calculated), %
$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4(\alpha\text{-Pic})_2$	70	20.4/20.2
$\text{Mo}_2(\text{O}_2\text{CH})_4(\alpha\text{-Pic})_2$	135	32.6/33.3
$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4\text{Q}_2$	90	26.5/26.0
$\text{Mo}_2(\text{O}_2\text{CH})_4\text{Q}_2$	158	40.8/40.0
$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4(\beta\text{-Pic})_2$	98	20.9/20.2
$\text{Mo}_2(\text{O}_2\text{CH})_4(\beta\text{-Pic})_2$	160	33.7/33.3
$\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4(4\text{-VinP}_y)_2$	100	23.0/22.2
$\text{Mo}_2(\text{O}_2\text{CH})_4(4\text{-VinP}_y)_2$	140	34.4/36.0

The behavior of the complexes by heating is characterized by the following features. Firstly, the removal temperature of L' molecules for tetra- $\mu_2$ -phenylacetate complexes is 40-60 °C lower than for the appropriate formate derivatives [12]. Secondly, the elimination of ligand L' in them does not cause a significant change in the properties of the complexes: the appearance and light yellow color of the substances are preserved. However, the removal of L'' ligands from tetra- $\mu_2$ -formate complexes

of dimolybdenum is accompanied by the color change from light yellow to dark green, which is probably the result of the change in the coordination of the formate ligands. Thirdly, for all phenylacetate derivatives, with the exception of the complex with  $\alpha$ -Pic, the removal temperature of ligand L' does not depend on their donor ability. Apparently this is due to additional interactions between the L' axial ( $\alpha$ -Pic) and equatorial ligands.

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## TETRA- $\mu_2$ -FENİLASETATODİMOLİBDEN KOMPLEKSİNİN VƏ ONUN TÖRƏMƏLƏRİNİN İQ SPEKTRLƏRİ

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**Xülasə:** Təqdim olunan məqalədə tetra- $\mu_2$ -fenilasetatodimolibden  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$  və onun törəmələri olan  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}_2'$  [ $\text{L}' = \alpha$ -,  $\beta$ -pikolin ( $\alpha$ -,  $\beta$ -Pic), 4-vinilpiridin (4-VinPy), xinolin (Q)] tərkibli klaster birləşmələrin sintezi, termiki və spektral xarakteristikaları verilmişdir. Sintez olunmuş  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4\text{L}'$ - tərkibli komplekslərin və maye halda olan  $\text{L}'$ -liqandlarının İQ-spektrlərinin müqayisəsi göstərir ki, onlar bir-birinə çox oxşardır. Belə ki, sərbəst  $\text{L}'$  liqandlara məxsus hər bir udma zolaqları onlar əsasında sintez olunmuş  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}_2'$  tərkibli adduktların İQ-spektrində müəyyən dərəcədə sürüşməyə və ya bir necə nazik zolaqlara ayrılmaya məruz qalırlar. Lakin  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}_2'$  və əvvəllər bizim tərəfimizdən sintez olunan  $\text{Mo}_2(\text{O}_2\text{CH})_4\text{L}_2''$  [1][ $\text{L}'$  və  $\text{L}'' = \alpha$ -,  $\beta$ -Pic, 4-VinPy, Q] tərkibli komplekslərin İQ spektrlərinin müqayisəsi göstərir ki, spektrdə  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}_2'$  tərkibli adduktların da spektrlərində aksial vəziyyətlərdə yerləşmiş heterotsiklik həlqələrin valent rəqslərinə –  $\nu(\text{həlqəyə})$  aid udma zolaqlarının spektrin kiçin dalğa uzunluğu tərəfə sürüşmələri baş verir. İQ-spektrlərdə bundan başqa, tsiklik həlqələrdəki C – H, C – C rabitələrinin müstəvi və qeyri-müstəvi deformasiya rəqslərinə uyğun udma zolaqlarının da sürüşməsi baş verir. Lakin qeyd olunan udma zolaqlarının

kiçik dalğa uzunluğu tərəfə sürüşmələri kiçik qiymətlərlə səciyyələnir. Bu nəticə isə onu söyləməyə dəlalət edir ki, qeyd olunan  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  tərkibli adduktlarda aksial vəziyyətlərdəki Mo – L' koordinativ rabitələr zəifdir. Bundan başqa, müəyyən edilmişdir ki,  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  tərkibli adduktları qızdırdıqda L'-liqandlarının tam ayrılması 70 –100 °C arasında baş verir və hər bir nümunə müvafiq temperaturda ~ 2 saat ərzində qızdırıldıqdan sonra onun İQ spektri ilkin tetra- $\mu_2$ -fenilasetatodimolibden kompleksinin spektri ilə tam üst-üstə düşür.

**Açar sözlər:** fenilasetat, dimolibden,  $\alpha$ - və  $\beta$ -pikolin, valent və deformasion rəqslər, termoliz

## ИК-СПЕКТРЫ КОМПЛЕКСА ТЕТРА- $\mu_2$ -ФЕНИЛАЦЕТАТОДИМОЛИБДЕНА И ЕГО ПРОИЗВОДНЫХ

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**Аннотация:** В работе описаны синтез, термические и спектральные характеристики тетра- $\mu_2$ -фенилацетатного комплекса димolibдена –  $\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4$  и его производных типа  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  [где L' =  $\alpha$ -,  $\beta$ -пиколин ( $\alpha$ -,  $\beta$ -Pic), 4-винилпиридин (4-VinPy), хинолин (Q)]. Сравнение ИК-спектров синтезированных комплексов  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  со спектрами жидких L' лигандов позволяет обнаружить их большое сходство. Почти каждая полоса в ИК-спектре свободных L' лигандов воспроизводится в спектре комплекса с незначительным длинноволновым смещением или расщеплением, что является следствием координации L' через гетероатомом азота. Однако, при сравнении величин смещения частот валентных колебаний  $\nu_{(\text{кольца})}$ , неплоских и плоских деформационных колебаний связей C-H и C-C гетероциклических колец, а также значений деформационных колебаний частот  $\delta(\text{CCC})$ ,  $\delta(\text{CNC})$  в спектре комплексов  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$ , а также полученного нами ранее комплекса  $[\text{Mo}_2(\text{O}_2\text{CH})_4]\text{L}''_2$  [1] [где, L' и L'' =  $\alpha$ -,  $\beta$ -Pic, 4-VinPy, Q], можно отметить, что координационные связи Mo-L' в аксиальных положениях в указанных аддуктах слабые. Кроме того, установлено, что при нагревании аддуктов состава  $[\text{Mo}_2(\text{O}_2\text{CCH}_2\text{C}_6\text{H}_5)_4]\text{L}'_2$  происходит полное удаление L'-лигандов при 70-100°C. После нагревания каждого образца при соответствующей температуре в течение 2 часов их ИК-спектр полностью совпадал со спектром исходного тетра- $\mu_2$ -фенилацетатодимolibденового комплекса.

**Ключевые слова:** фенилацетат, димolibден,  $\alpha$ - и  $\beta$ -пиколин, валентные и деформационные колебания, термолиз