

## SYNTHESIS AND STRUCTURE OF HETEROMETALLIC MULTILIGAND Ge(IV) - 3d-METALS COMPLEXES WITH 1-HYDROXYETHANE-1,1- DIPHOSPHONIC ACID AND 1,10-PHENANTHROLINE

Kyrylo Tsymbaliuk <sup>a,b</sup>, Olena Martsynko <sup>ib a\*</sup>, Viktoriya Dyakonenko <sup>ib c</sup>, Olena Finik <sup>ib b</sup>,  
Inna Seifullina <sup>ib a</sup>, Svitlana Shishkina <sup>ib c,d</sup>

<sup>a</sup>Odesa I.I. Mechnikov National University, 2, Dvoryanska str., Odesa, 65082, Ukraine

<sup>b</sup>LLC "Inspectorat Ukraine", 1, Udilny Lane, Odesa, 65044, Ukraine

<sup>c</sup>SSI "Institute for Single Crystals", National Academy of Sciences of Ukraine,  
60, Nauki ave., Kharkov, 61001, Ukraine

<sup>d</sup>Institute of Organic Chemistry, National Academy of Sciences of Ukraine,  
5, Akademika Kukharya str., Kyiv, 02660, Ukraine

\*e-mail: [lborn@ukr.net](mailto:lborn@ukr.net)

**Abstract.** Synthesis methods were developed, five new coordination compounds were isolated and investigated:  $[M(\text{phen})_3]_4[\text{Ge}_6(\mu\text{-OH})_4(\mu\text{-O})_2(\mu\text{-hedp})_6] \cdot x\text{CH}_3\text{COOH} \cdot n\text{H}_2\text{O}$  (M= Fe (**1**),  $x=0$ ,  $n=20$ ; Co (**2**),  $x=2$ ,  $n=30$ ; Ni (**3**),  $x=2$ ,  $n=26$ ),  $[\text{Cu}(\text{phen})_2(\text{H}_2\text{O})]_2[\text{Cu}(\text{phen})(\text{H}_2\text{O})_3]_2[\text{Ge}_6(\mu\text{-OH})_4(\mu\text{-O})_2(\mu\text{-hedp})_6] \cdot 16\text{H}_2\text{O}$  (**4**),  $[\text{Zn}(\text{phen})_2(\text{H}_2\text{O})_2]_2[\text{Zn}(\text{phen})(\text{H}_2\text{O})_4]_2[\text{Ge}_6(\mu\text{-OH})_4(\mu\text{-O})_2(\mu\text{-hedp})_6] \cdot 18\text{H}_2\text{O}$  (**5**), were  $\text{H}_4\text{hedp}$  - 1-hydroxyethane-1,1-diphosphonic acid, phen - 1,10-phenanthroline. It was found that the complexes belong to the cation-anion type, consisting of the hexanuclear complex anion, in which Ge atoms are connected by three types of bridging ligands (hydroxy-, oxo-, and 1-hydroxyethane-1,1-diphosphonate), and phenanthroline-containing cations of different compositions depending on the 3d-metal. Synthesized substances in crystals are organic-inorganic hybrid ensembles with three-dimensional networks formed by numerous intermolecular hydrogen bonds between complex cations, anions, and water of crystallization molecules.

**Keywords:** 1-hydroxyethane-1,1-diphosphonic acid, 1,10-phenanthroline, germanium, 3d-metal, crystal structure.

Received: 07 October 2024/ Revised final: 14 November 2024/ Accepted: 18 November 2024

---