

## Hybrid Links between Decavanadates and Betaines of Potential Pharmacological Relevance

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### Abstract

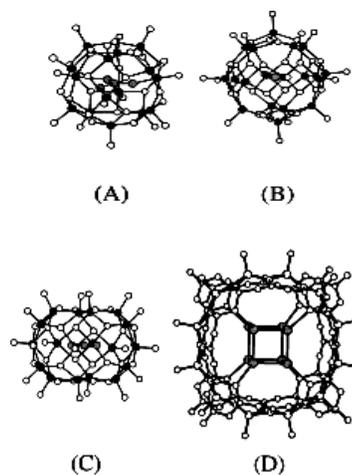
In the present research account, three new binary hybrid decavanadate compounds were synthesized. In these three complexes, vanadium occurs in the fully oxidized +5 state and the color of the crystals is orange-red. In the synthesis of the crystalline solids, the reaction mixture pH appears to be a major factor in the synthetic isolation and crystallization of the specific compound exhibiting variable lattices. Spectroscopic, structural and electrochemical characterization techniques, and biological studies currently in progress reveal a) the unique properties of the variably crystallized polyoxovanadate-betaine binary lattice structures, and b) attest to their potential in physiological functions of pharmacological significance.

**Keywords:** Vanadium, polyoxo, decavanadate, trimethylglycine

### 1. Introduction

Vanadium is an element that occurs naturally in about 65 different minerals and in fossil fuel deposits. It is mainly used to produce specialty steel alloys such as high speed tool steels. The compound vanadium pentoxide is used as a catalyst for the production of sulfuric acid. Vanadium is found in many organisms and is used by some life forms as an active site center of enzymes.

Vanadium compounds with appropriate physiological ligands (low molecular as well as high molecular mass) have been proven to provide low toxicity, good absorption rates, bio-recognition and high insulin-mimetic potency [1-4].



**Figure 1.** Structures of spherical cluster anions produced by photoinduced self-assembly encapsulation: (A)  $[\text{V}_{15}\text{O}_{36}(\text{CO}_3)]^{7-}$ , (B)  $[\text{V}_{18}\text{O}_{42}(\text{Cl})]^{13-}$ , (C)  $[\text{V}_{18}\text{O}_{44}(\text{N}_3)]^{14-}$  and (D)  $[\text{V}_{12}\text{B}_{32}\text{O}_{76}(\text{OH})_8(\text{Na}_4)]^{7-}$

It is a well-known fact that the polyoxovanadates are an interesting class of inorganic materials with applications in diverse areas such as biology, medicine, materials science [1]. Polyoxometalates are of physiological and of pharmacological relevance. Although most of them are not likely to be present in normal physiological conditions, their formation in response to a high metal concentration could be an effective detoxification mechanism. Furthermore, being able to traverse effectively through cell surface, polyoxovanadates exhibit antiviral and anti-HIV activities [2, 3]. In weakly acidic solution ( $\text{pH} < 6$ ), the major species are the orange decavanadate anions.

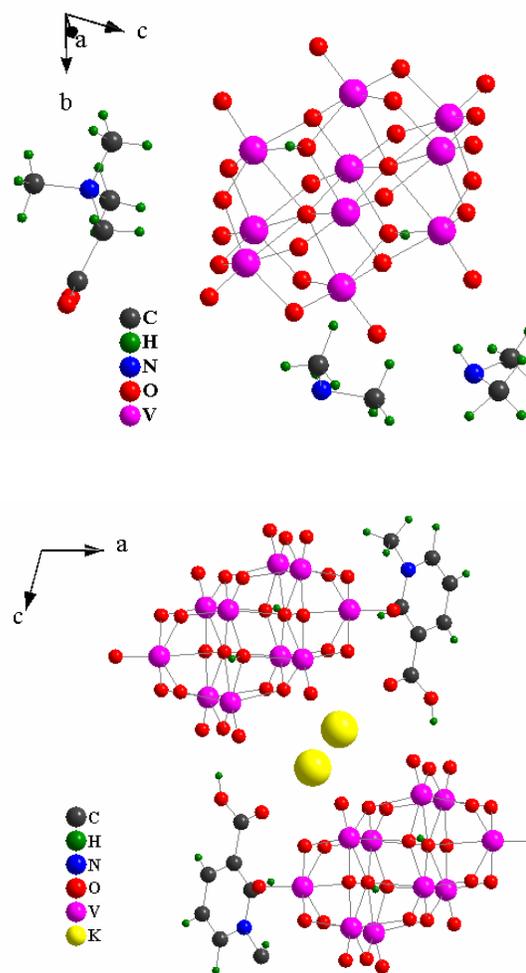
## 2. Materials and methods

All experiments were carried out under aerobic conditions. Nanopure quality water was used for all reactions.  $\text{V}_2\text{O}_5$ , glycine, and  $\text{H}_2\text{O}_2$  30% were purchased from Aldrich. Sodium, ammonia and potassium hydroxide were supplied by Fluka.

## 3. Results and Discussion

In the present research account, new binary hybrid compounds were synthesized. The synthetic conditions involved reaction of  $\text{V}_2\text{O}_5$  solubilized by the appropriate base and adding the appropriate ligand (e.g. zwitterion) followed by adjustment of the reaction mixture pH, for which the final product would be crystallized. On all cases attempts were made to pursue the synthesis of the decavanadate-containing materials both at room temperature as well as under hydrothermal conditions [4]. Isolation and crystallization of the final product was achieved in the presence of the precipitating solvent ethanol. Surprisingly, in all complexes isolated, vanadium occurs in the fully oxidized +5 state and the color of the crystals is orange-red. In all cases of pursued syntheses, the reaction mixture pH appears to be a major factor in the synthetic isolation and crystallization of the specific compound exhibiting betaine-containing lattices.

The X-ray crystal structures of the crystalline products consist of discrete anions and cations in the respective lattices. The crystal structure diagrams of the complexes are shown in Fig. 2-3.



**Figure 2.** Diamond diagrams of V(V)-Trigonelline and V(V)-(Gly-Bet) Cluster

Analytical and spectroscopic techniques were employed for the physicochemical characterization of all crystalline solids synthesized in this work. The FT-infrared spectra of all compounds exhibit strong absorptions for the carboxylate carbonyls of the employed carboxylate-containing ligands. Specifically, the antisymmetric stretching vibrations  $\nu_{\text{as}}(\text{COO}^-)$  emerge in the range from 1700 to 1390  $\text{cm}^{-1}$ . The symmetric stretches  $\nu_{\text{s}}(\text{COO}^-)$  appear in the range from 1475 to 1385  $\text{cm}^{-1}$ . The vibrations in V(V)-peroxo complexes are observed in the spectral windows of 920-1000, 660-440, and 800-940  $\text{cm}^{-1}$ , respectively. The FT-IR spectrum of  $\text{K}_2[\text{V}_{10}\text{O}_{28}\text{H}_2][\text{C}_5\text{H}_4\text{N}(\text{Me})\text{COOH}]_2$  is shown in the Figure 3.

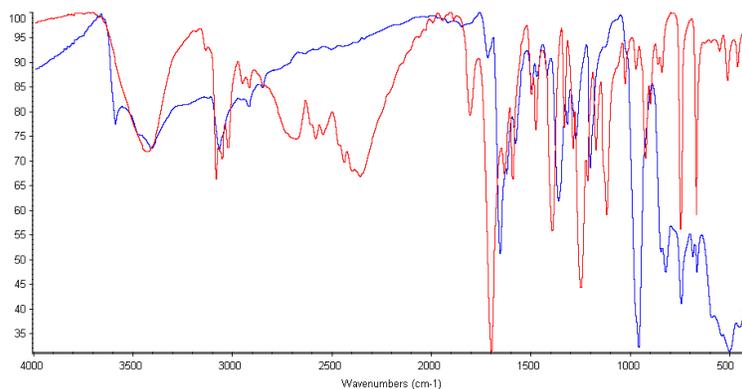


Figure 3. FT-IR spectroscopy of  $K_2[V_{10}O_{28}H_2][C_5H_4N(Me)COOH]_2$

#### 4. Conclusion

New synthetic approaches were employed for the synthesis and isolation of decavanadate compounds of variable nature ligands including betaines. Spectroscopic, structural and electrochemical characterization techniques and biological studies currently in progress on all new synthetic compounds reveal a) the unique properties of the variably crystallized polyoxovanadate-betaine binary lattice structures, and b) attest to their potential as support carriers in physiological functions of pharmacological significance. Further perusal of structural, electronic and spectroscopic properties of polyoxovanadate-betaine species may provide a physicochemical basis of comprehending and/or potentially predicting-tuning the factors dictating the insulin mimetic capacity of vanadium in the presence of physiological ligands. Induction of their formation in response to metal concentration could constitute an effective detoxification mechanism. Collectively, polyoxovanadate complexes [5-8] are an interesting class of inorganic materials with applications in diverse areas of biology, medicine, and materials science.

#### Acknowledgements

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