



**PHYSICAL CHEMISTRY 2018**

14<sup>th</sup> International Conference  
on Fundamental and Applied Aspects of  
Physical Chemistry

Proceedings  
Volume I

**September 24-28, 2018**  
**Belgrade, Serbia**





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**ISBN** 978-86-82475-36-1

**Title:** Physical Chemistry 2018 (Proceedings)

**Editors:** Željko Čupić and Slobodan Anić

**Published by:** Society of Physical Chemists of Serbia, Studentski Trg 12-16,  
11158, Belgrade, Serbia

**Publisher:** Society of Physical Chemists of Serbia

**For Publisher:** S. Anić, President of Society of Physical Chemists of Serbia

**Printed by:** "Jovan", <Printing and Publishing Company, 200 Copies

**Number of pages:** 550+6, Format B5, printing finished in September 2018

Text and Layout: "Jovan"

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# PHYSICAL CHEMISTRY 2018

*14<sup>th</sup> International Conference on  
Fundamental and Applied Aspects of  
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*Organized by*

*The Society of Physical Chemists of  
Serbia*

*in co-operation with*

*Institute of Catalysis Bulgarian Academy of Sciences*

*and*

*Boriskov Institute of Catalysis Siberian Branch of  
Russian Academy of Sciences*

*and*

*University of Belgrade, Serbia:*

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## EFFECT OF POLYOXOMETALATES ON SYNAPTIC PLASMA MEMBRANE STRUCTURE

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### ABSTRACT

12-tungstosilicic acid (SiW12) and decavanadate (V10) are polyoxometalate compounds (POMs) exhibiting biological activity. *In vitro* studies of the influence SiW12 and V10 on synaptic plasma membrane (SPM) acetylcholinesterase (AChE) and Na,K-ATPase, respectively, showed that these POMs inhibit the enzyme activities in submicromolar concentrations. As Na,K-ATPase and AChE are membrane associated enzymes, the inhibition of their activities can result from the membrane changes induced by the inhibitor binding. Thus, the effect of SiW12 and V10 on the membrane structure was investigated by using Atomic Force Microscopy (AFM) technique. The obtained results demonstrated that the calculated average roughness values for SiW12 and V10 treated SPM were significantly higher (about 6 and 1.5 times, respectively), compared to untreated SPM preparation. The obtained changes indicate that both investigated POMs bind to the plasma membranes, and consequently their approved strong inhibitory potencies toward the membrane bound enzymes might be assigned to the induced membrane modifications.

### INTRODUCTION

Decavanadate (V10) and 12-tungstosilicic acid (SiW12) are polyoxometalates (POMs), negatively charged inorganic compounds containing early transition metal ions in their highest oxidation state, surrounded by oxygen atoms [1]. POMs have been shown to exhibit biological activities *in vitro* as well as *in vivo* [2-5]. However, their biological mechanisms of action at the molecular level are not well understood [6]. It has been speculated that POMs are likely to act extracellularly inhibiting several different enzyme families mostly located on the plasma membrane and display extracellular binding sites [7].

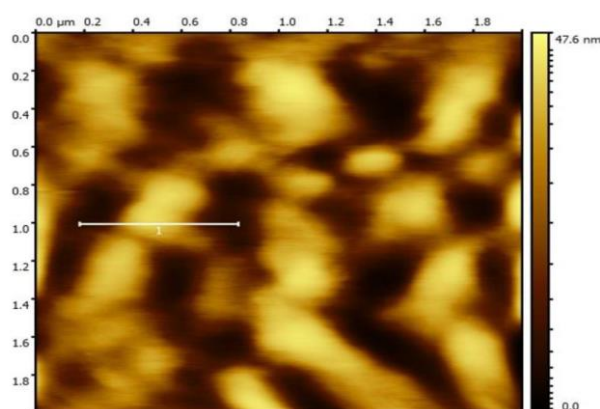
The results of inhibitory influence of V10 and SiW12 on synaptic plasma membrane (SPM) acetylcholinesterase (AChE) and Na,K-ATPase showed that V10 induces 50% decrease in Na,K-ATPase activity at concentration of  $5 \times 10^{-7}$  mol/L ( $IC_{50}$ ) [8], while  $IC_{50}$  value of  $6.2 \times 10^{-8}$  mol/L SiW12 for AChE was obtained. However, the structural and conformational modifications of these membrane enzymes in the presence of the tested polyoxometalates, which are expected to influence the activity, were not clarified. Furthermore, the activities of Na,K-ATPase as a transmembrane enzyme and AChE as a membrane bound enzyme might be modified due to some membrane changes induced by the inhibitor binding. Therefore, the aim of this study is to investigate the influence of SiW12 and V10 on the SPM structure by using Atomic Force Microscopy (AFM) technique.

### EXPERIMENTAL

SiW12 ( $H_4SiW_{12}O_{40}$ ) was commercially available (Sigma Aldrich), and V10 ( $(NH_4)_6V_{10}O_{28} \cdot 5H_2O$ ) was synthesized [8, 9]. Stock solutions of SiW12 and V10 (0.01 mol/L) were prepared daily, by solving the solid compounds in water shortly before use. Working solutions (0.001 mol/L) were prepared daily by diluting the stock solutions. SPM were isolated from the whole brain of 3-month-old male *Wistar albino* rats according to the method of Towle and Sze [10]. Preliminary studies showed that the presence of  $5 \times 10^{-4}$  mol/L SiW12 did not change pH of the SPM preparation (7.4). 50  $\mu$ L of SPM preparation was mixed with 50  $\mu$ L of 0.001 mol/L investigated POM solution (1:1), and then applied in drops onto a glass surface. The SPM preparation in combination with water (1:1) served as a control. The prepared samples dried overnight. AFM measurements were performed using a home-designed microscope [11] that can be operated under controlled environmental conditions. The AFM measurements were performed in air, at room temperature and constant 30% relative humidity. The contact mode measurements were performed in the weak repulsive regime of constant force with a probe force below 1 nN from zero cantilever deflection. The high-resolution images have been collected at a scanning speed of 0.25–0.35 Hz.

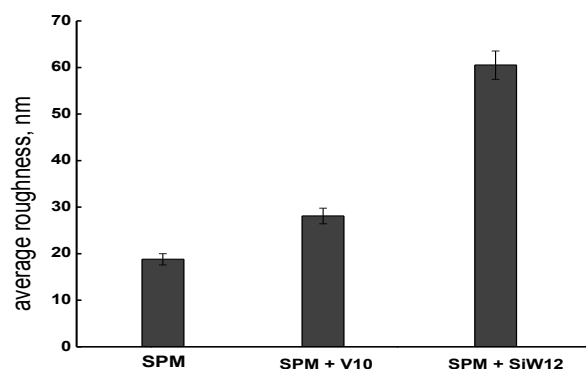
### RESULTS AND DISCUSSION

The image of the control SPM sample (without POM) obtained by AFM technique is presented in Fig. 1.



*Figure 1. The image of the control SPM sample obtained by AFM technique.*

The values of average roughness for the investigated POM (V10, SiW12)-SPM samples and control SPM were calculated and presented in Fig. 2. The obtained results demonstrate that the roughness value for the SPMs after SiW12 treatment significantly increased, more than 3 times, compared to the membrane roughness before the SiW12 treatment (SPM alone). The presence of V10 also induced increase in the membrane roughness compared to the SPM control, but about 1.5 times.



**Figure 2.** The calculated values of average roughness obtained for SPMs before (SPM) and after V10 (SPM + V10), and SiW12 (SPM + SiW12), treatment.

The obtained results indicate that both SiW12 and V10 bind to the plasma membranes. Consequently, their previously approved strong inhibitory potencies ( $IC_{50}$  values in submicromolar concentrations) toward the

membrane bound enzymes (AChE and Na,K-ATPase) might be assigned to the induced membrane modifications.

### CONCLUSION

The investigated polyoxometalates in this study, SiW12 and V10, inhibit the activities of membrane associated enzymes, SPM AChE and Na,K-ATPase in submicromolar concentrations, respectively. The results obtained by AFM technique demonstrate that both SiW12 and V10 induce increase in average roughness values of SPM compared to untreated SPM. Accordingly, it could be concluded that these compounds modify the plasma membrane structure, resulting in the affection of the membrane associated enzyme activities.

### *Acknowledgement*

This study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Project No. 172023), and COST Action MP1302.

### REFERENCES

- [1] B. Hasenknopf, *Front. Biosci.*, 2005, **10**, 275–287.
- [2] X. Wang, J. Liu, J. Li, Y. Yang, J. Liu, B. Li, et al. *J. Inorg. Biochem.*, 2003, **94**, 279–284.
- [3] A. Seko, T. Yamase, K. Yamashita, *J. Inorg. Biochem.*, 2009, **103**, 1061–1066.
- [4] Y. Qi, Y. Xiang, J. Wang, Y. Qi, J. Li, J. Niu, et al. *Antiviral. Res.*, 2013, **100**, 392–398.
- [5] M. Aureliano, D.C. Crans, *J. Inorg. Biochem.*, 2009, **103**, 536–546.
- [6] R. Prudent, V. Moucadel, B. Laudet, C. Barette, L. Lafanechere, B. Hasenknopf, et al. *Chem. Biol.*, 2008, **15**, 683–692.
- [7] S-Y. Lee, A. Fiene, W. Li, T. Hanck, K. Brylev, V. Fedorov, et al. *Biochem. Pharmacol.*, 2015, **93**, 171–181.
- [8] D. Krstić, M. Čolović, N. Bošnjaković-Pavlović, A. Spasojević-de Bire, V. Vasić, *Gen. Physiol. Biophys.*, 2009, **28**, 302–308.
- [9] B. Chinea, D. Dakternieks, A. Duthie, C.A. Ghilardi, P. Gili, A. Mederos, S. Midollini, A. Orlandini, *Inorg. Chim. Acta*, 2000, **298**, 172–177.
- [10] A.C. Towle, P.Y. Sze, *J. Steroid Biochem.*, 1983, **18**, 135–143.
- [11] A. Cricenti, R. Generosi, *Rev. Sci. Instrum.*, 1995, **66**, 2843–2847.

CIP - Каталогизација у публикацији - Народна библиотека Србије, Београд

544(082)

621.35(082)

577.3(082)

543.42(082)

INTERNATIONAL Conference on Fundamental and Applied Aspects of Physical Chemistry (14 ; 2018 ; Beograd)

Physical Chemistry 2018 : proceedings. Vol. 1 / 14th International

Conference on Fundamental and Applied Aspects of Physical Chemistry,

September 24-28, 2018, Belgrade ; [editors Željko Čupić and Slobodan Anić].

- Belgrade : Society of Physical Chemists of Serbia, 2016 (Belgrade :

Jovan). - VI, 550 str. : ilustr. ; 24 cm

Tiraž 200. - Bibliografija uz svaki rad.

ISBN 978-86-82475-36-1

1. Society of Physical Chemists of Serbia (Beograd)

a) Физичка хемија - Зборници b) Електрохемијско инжењерство - Зборници

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COBISS.SR-ID 267528204