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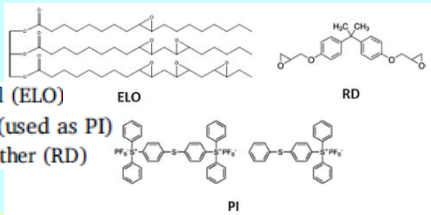
Investigating the network properties of polymer matrixes for controlling a functionality of laccase-based amperometric biosensors

T. Kavetskyy[1,2], Y. Kukhazh[1], K. Zubrytska[1], E. Krasnevych[1], O. Shakalets[1], V. Boev[3], V. Ilcheva[3], T. Petkova[3], S. Kasetaite[4], J. Ostrauskaite[4], H. Švajdlenková[5], O. Šauša[6]

[1]*Drohobych Ivan Franko State Pedagogical University, 82100 Drohobych, Ukraine*
[2]*The John Paul II Catholic University of Lublin, 20-950 Lublin , Poland*
[3]*Institute of Electrochemistry and Energy Systems, BAS, 1113 Sofia, Bulgaria*
[4]*Kaunas University of Technology, 50254 Kaunas, Lithuania*
[5]*Polymer Institute, Slovak Academy of Sciences, 84541 Bratislava, Slovakia*
[6]*Institute of Physics, Slovak Academy of Sciences, 84511 Bratislava, Slovakia*



Motivation

The new direction in analytical biotechnology is the development of biosensors – bioanalytical devices that combine the best features of bioelements (selectivity) and physical transducers (high sensitivity and accuracy). Biosensors are complicated and effective device capable of fast detection and measuring wide spectrum in various applications in the field of healthcare, industrial process control, military application, environmental monitoring, agriculture and veterinary monitoring. Application of polymer as a holding matrix of immobilized enzyme is an innovative approach in a construction of the non-mediated enzyme-based biosensors of the third generation [1].

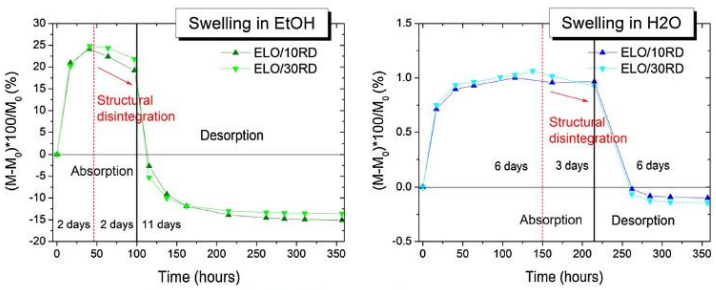


Fig. 2. The absorption and desorption of EtOH (left) and H_2O (right) of the polymers ELO/10RD and ELO/30RD during 15 days.

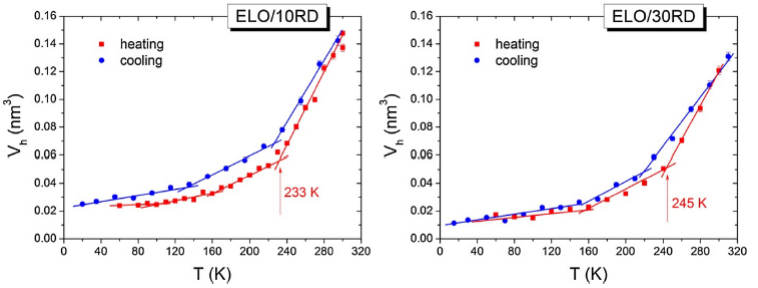


Fig. 3. Hole volume temperature dependences $V_h(T)$ for the polymers ELO/10RD (left) and ELO/30RD (right) in the heating and cooling cycles.

Table 2

Hole volume V_h at glass transition temperature T_g, swellability S in EtOH, and slopes α_{F1}, α_{F2} of the $V_h(T)$ dependences in the regions below and above T_g, respectively, as well as their differences. Values for heating and cooling cycles are in the top and bottom part of the boxes, respectively.

Polymers	V_h (nm^3)	T_g (K)	S (%)	α_{F1} (10^{-4}K^{-1})	α_{F2} (10^{-4}K^{-1})	$\alpha_{F2} - \alpha_{F1}$ (10^{-4}K^{-1})
ELO/10RD	0.057 ± 0.002 0.068 ± 0.002	233	24.09	3.53 ± 0.30 3.31 ± 0.32	13.02 ± 0.60 11.16 ± 0.55	9.49 ± 0.67 7.85 ± 0.64
ELO/30RD	0.051 ± 0.002 0.049 ± 0.002	245	24.81	3.47 ± 0.33 3.87 ± 0.83	12.42 ± 0.64 8.96 ± 0.48	8.95 ± 0.72 5.09 ± 0.96

Table 3

Biosensor response I_{max}, apparent Michaelis-Menten constant K_M^{app} toward ABTS as the substrate, the slope of the calibration curve B, the sensitivity of bioelectrodes (working surface area 7.35 mm^2) constructed based on laccase immobilized by the polymers ELO/10RD and ELO/30RD, and the range of linearity of the constructed bioelectrodes to ABTS.

Polymers	I_{max} (μA)	K_M^{app} (mM)	B (μA·mM^{-1})	Sensitivity (A·M^{-1}·m^{-2})	Range of linearity (mM)
ELO/10RD	4.9 ± 0.19	0.36 ± 0.03	12.3	1.673	0.006–0.15
ELO/30RD	1.25 ± 0.17	0.11 ± 0.04	9.07	1.234	0.025–0.10

Results and conclusion

In the present work, novel photocross-linked polymers are reported to be used in construction of laccase-based amperometric enzyme biosensors of the third generation for analysis of phenol derivates [2]. It is found that the polymer ELO/10RD compared to the polymer ELO/30RD has: (i) the higher crosslink density, (ii) the larger free-volume holes, (iii) the lower concentration of free-volume holes, and (iv) the larger difference in the coefficients for the thermal expansion of free-volume holes in the regions below and above T_g. At the same time, the laccase-based amperometric biosensor constructed using the polymer ELO/10RD as a biosensor holding matrix shows the improved biosensor's parameters compared to ELO/30RD. Further research is required to prove this correlation for other polymers with more different crosslink density.

References

[1] T. Kavetskyy et al., J. Appl. Polym. Sci., **134**, 45278 (2017).
[2] T. Kavetskyy et al., Eur. Polym. J., **115**, 391 (2019).

Acknowledgments

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