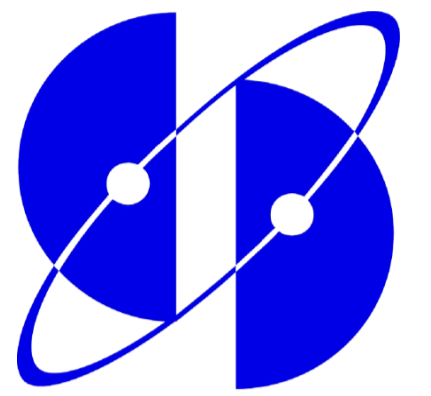


Electrochemical detection of lead and cadmium ions in water by sensors based on modified track-etched membranes

Nurdaulet Zhumanazar¹, Ilya V. Korolkov¹, Arman B. Yeszhanov¹, Dmitriy I. Shlimas¹, Maxim V. Zdorovets¹

nurdauletzhumanazar@gmail.com

¹Astana branch of the Institute of Nuclear Physics, Abylai-khan av., 2/1, 010008, Nur-Sultan, Kazakhstan

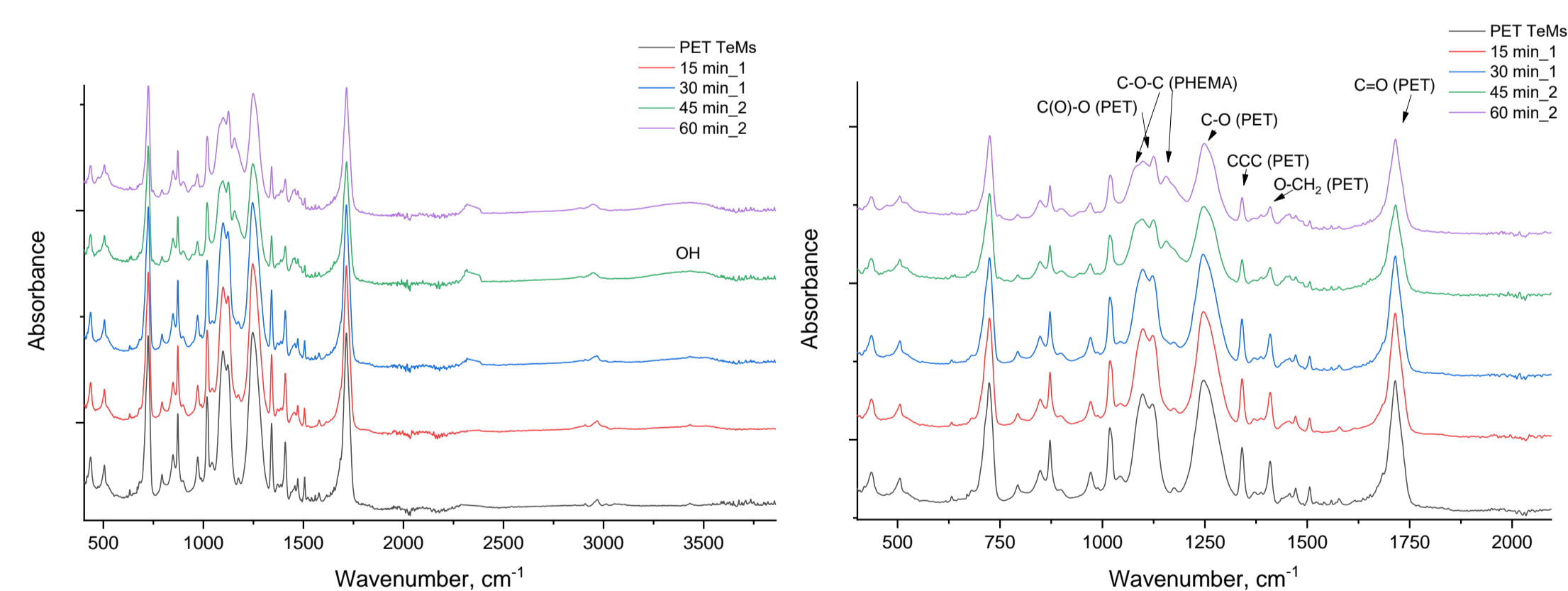
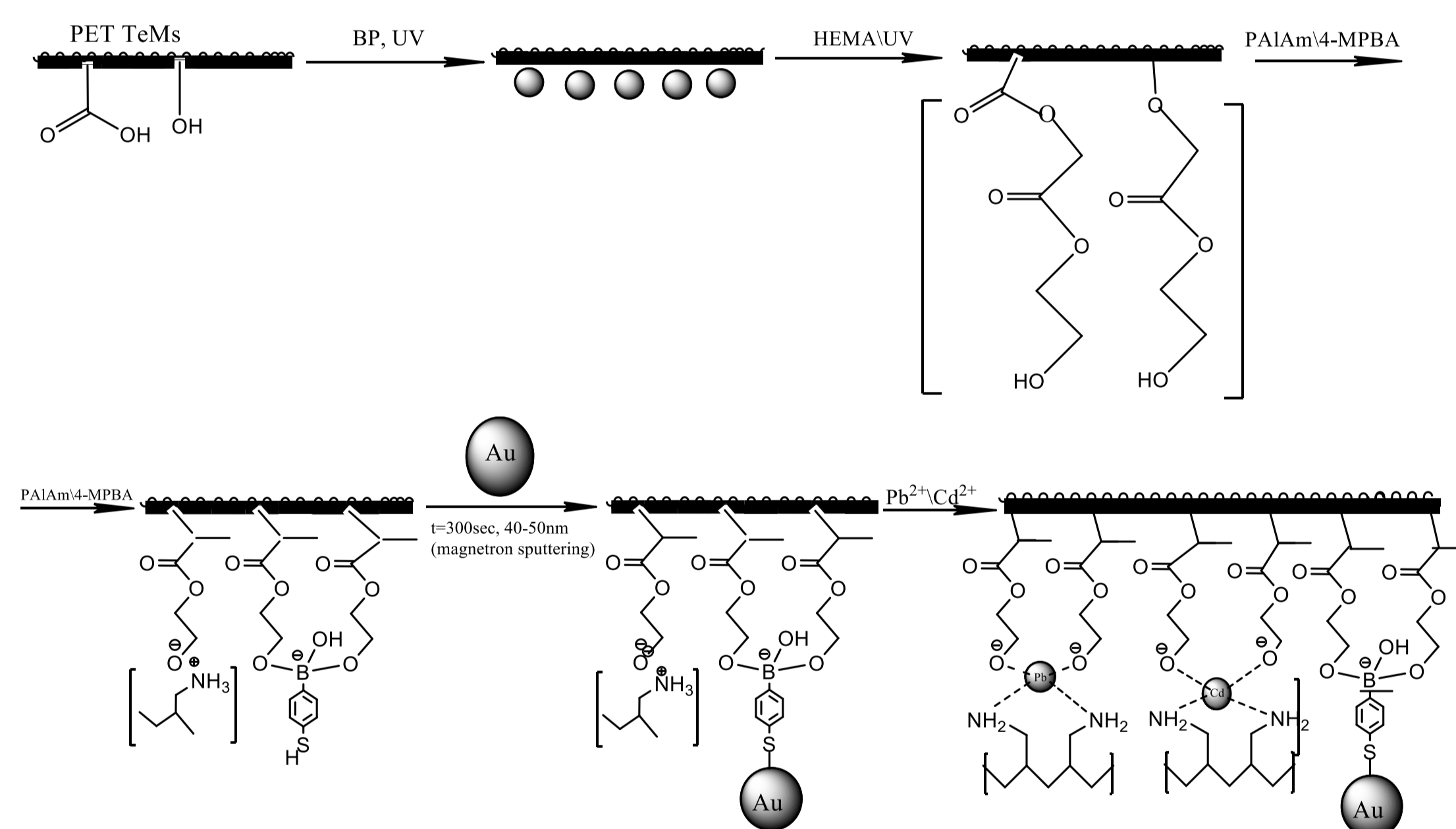


ABSTRACT AND INTRODUCTION

Electrochemical sensors based on PET track-etched membranes (TeMs) were prepared by photograft polymerization of 2-hydroxyethylmethacrylate (HEMA) and subsequent formation of interpolyelectrolyte complexes with poly(allylamine) (PAIAm). The modification, structure and properties of functionalized TeMs were characterized by scanning electron microscopy (SEM), FTIR spectroscopy, gas permeability and colorimetric assay. Parameters influencing the membrane's modification degree were estimated and optimized. Cd(II) and Pb(II) ions were detected by using square wave anodic stripping voltammetry (SW-ASV). Additional modification of the membranes with 4-mercaptophenylboronic acid (MPBA) led to increasing of stability of the sensors. The linear range for the detection of Cd(II) and Pb(II) ions using the modified electrode was 50 µg - 4.25 mg/L and 10 µg - 4.25 mg/L with limits of detection of 0.21 and 0.34 mg/L, respectively. Moreover, the obtained results of SW-ASV demonstrated that the enhancement in the electrochemical signals was achieved with PET TeMs-g-PHEMA-PAIAmMPBA compared to that of a bare PHEMA. Selectivity test showed that alkali and alkaline earth metal ions, except for magnesium (up to 1 mg/l), do not particularly interfere with the determination of lead and cadmium in the analyte. Sensing of Pb and Cd ions in river water demonstrate us that prepared sensors can be used in real conditions with sufficient accuracy and reproducibility of the results.

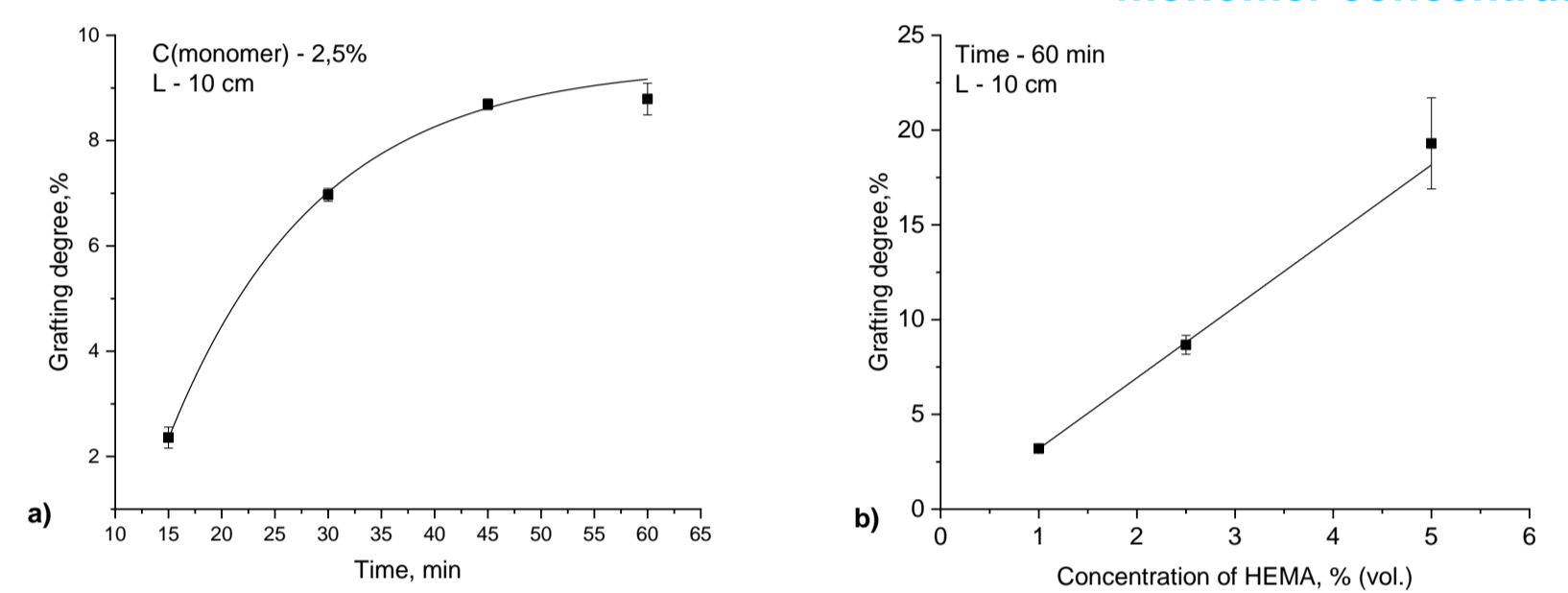
RESULTS AND DISCUSSION

PET TeMs were modified according to the scheme. At the first stage, graft polymerization of 2-HEMA was performed. Parameters that can influence to the grafting degree such as monomer concentration, reaction time and distance from the UV-lamp were optimized to get the highest grafting degree with maintaining the pore structure of the membranes.

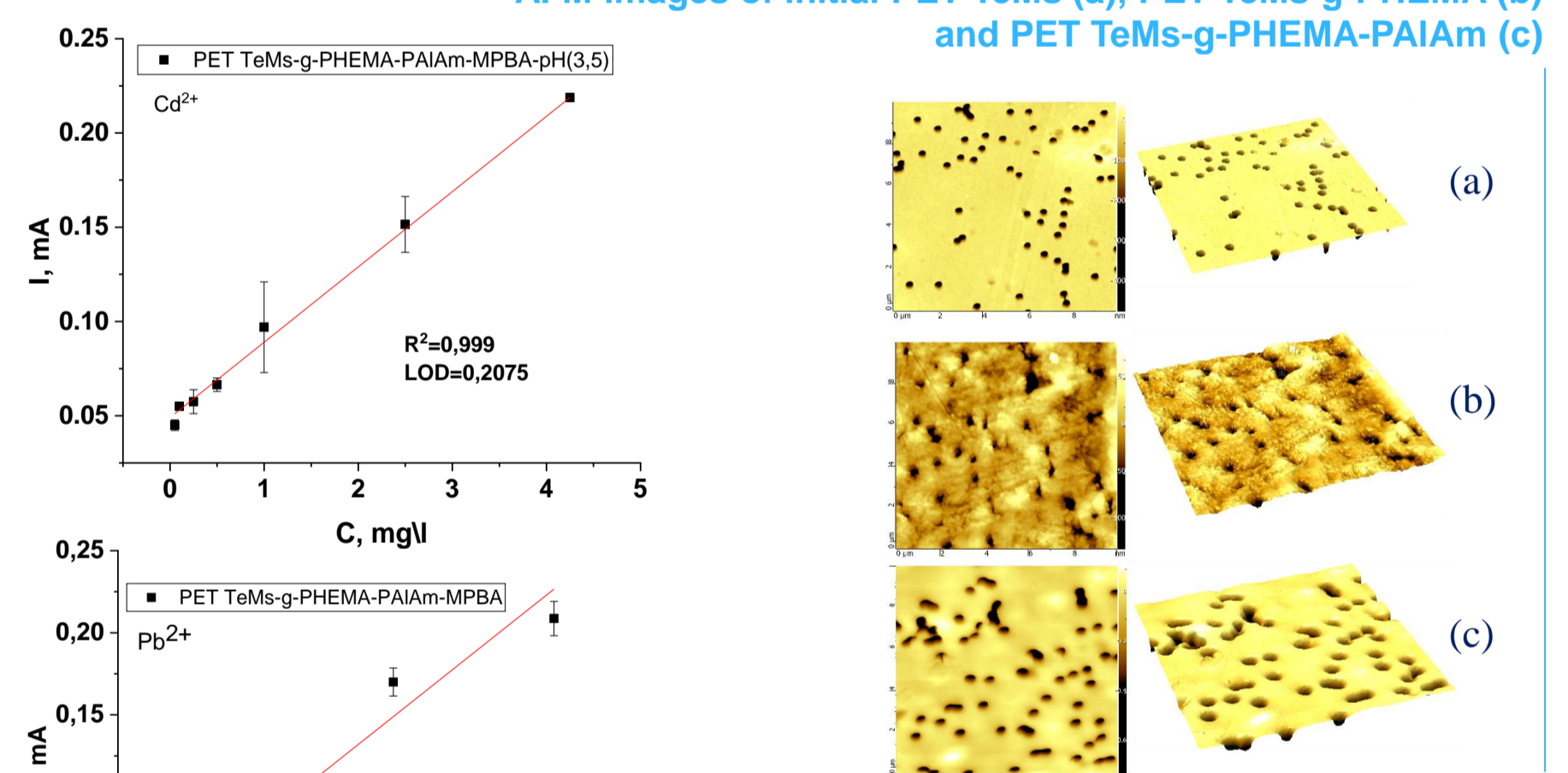


ATR-FTIR spectra of PET TeMs modified with PHEMA in the range from 4000 to 400 cm⁻¹ and absorption band

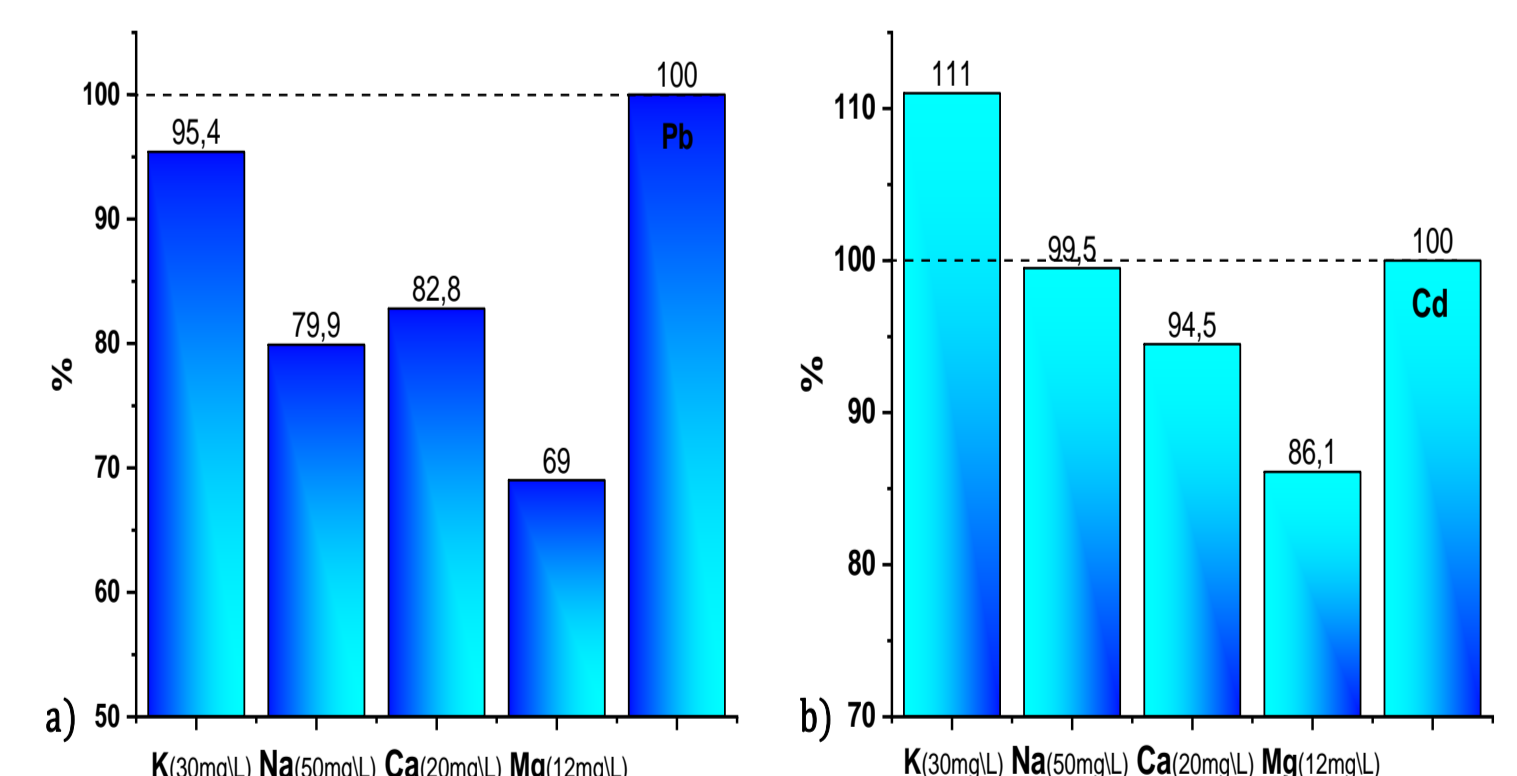
Grafting degree depends on irradiation time (a) and monomer concentration (b)



AFM images of initial PET TeMs (a), PET TeMs-g-PHEMA (b) and PET TeMs-g-PHEMA-PAIAm (c)



Calibration curves for Cd(II) and Pb(II) after 30 min of adsorption in the solution of Cd(II) and Pb(II) in 0.1 M sodium acetate electrolyte using sensors based on PET TeMs-g-PHEMA-PAIAm-MPBA



Influence of alkali and alkaline earth cations on the detection of Pb(II) and Cd(II) ions

CONCLUSION

In this research, we demonstrated that graft polymerization of 2-hydroxyethyl methacrylate and subsequent formation of interpolyelectrolyte complexes with poly(allylamine) on poly(ethylene terephthalate) track-etched membranes can improve properties of electrochemical sensors made based on this modified membranes. Prepared sensors were used for electrochemical detection of Pb and Cd ions using square wave anodic stripping voltammetry (SW-ASV) in the concentration range from 0.01 to 50 mg/L. Optimal conditions of modification were found leading to formation of anchors for heavy metal ions complexation and maintenance of pore structure of the membranes. The resulting sensors were used for the electrochemical detection of Pb²⁺ and Cd²⁺ ions using square wave anode stripping voltammetry in the range of linear concentrations from 0.01 to 4.25 mg/L).

Funding: This research is funded by the Ministry of Energy of the Republic of Kazakhstan (BR09158958)

Contacts: i.korolkov@inp.kz, +77051799083

REFERENCES

- V. Korolkov, N. Zhumanazar, Ye. G. Gorin, A. B. Yeszhanov, M.V. Zdorovets. Enhancement of electrochemical detection of Pb²⁺ by sensor based on track-etched membranes modified with interpolyelectrolyte complexes// J.Mater.Sci.Mater. Electron. – 2020, <https://doi.org/10.1007/s10854-020-04556-4>
- Sensors based on track-etched membranes for electrochemical detection of cadmium ions. <https://doi.org/10.52676/1729-7885-2021-1-5-8>

