The effect of amino acids on the degradation and oxidation of porous silicon in an aqueous medium

Shevchenko V.B.*, Datsenko O.I., Plyushchay I.V., Kuryliuk A.M.

Taras Shevchenko National University of Kyiv, Volodymyrska St. 64/13, Kyiv 01601, Ukraine

**victoriashevchenko@knu.ua*

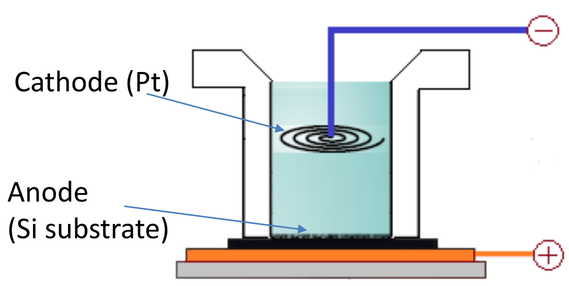
Introduction

Nanoporous silicon has unique physicochemical properties, simple manufacturing technology and good biocompatibility. Therefore, this material, like other siliceous materials, is promising for biomedical applications, such as biosensors, bioimaging and drug delivery [1]. Such applications require control of the degradation rate of silicon nanoparticles, which can be achieved by changing the porosity and pore size, as well as by functionalizing the surface with various compounds. It was proposed to use amino acids to modify the surface charges of silicon and silicon oxide nanoparticles [2]. Their advantages are biocompatibility and low toxicity.

In this work, the effect of amino acids on the degradation and oxidation of porous silicon in an aqueous medium is studied using photoluminescence (PL) of porous silicon (PS).

Samples

Porous silicon fabrication

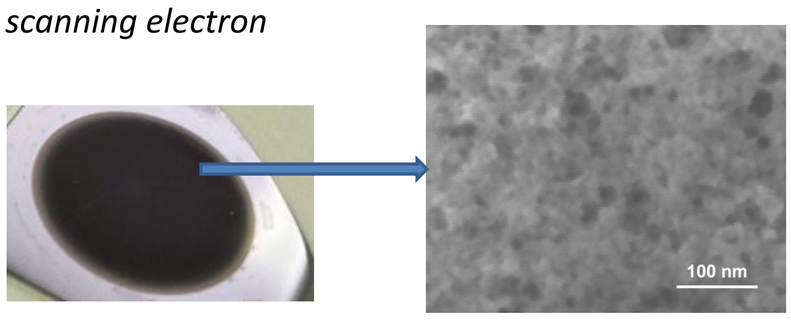


The schematic view of the electrochemical cell

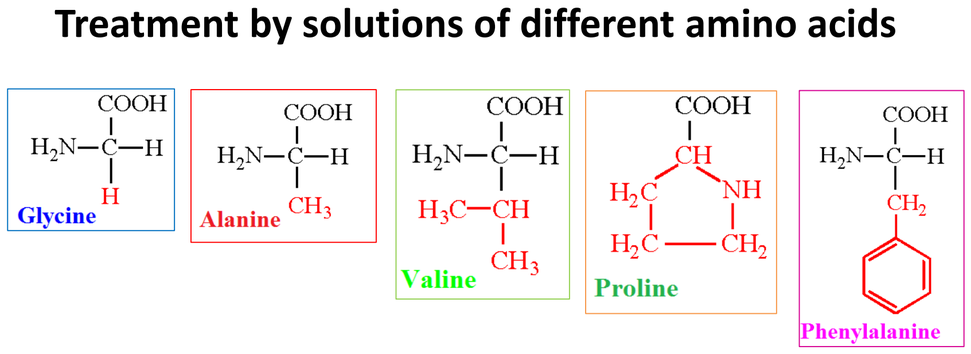
Nanoporous silicon samples were formed by electrochemical etching of p- type (100) silicon substrates with resistivity 10 Ohm*cm in an electrolyte based on a 48% water solution of (1:1) HF and C_2H_5OH. The samples were synthesized at etching current density (j) of 10 mA*cm^{-2}

The porosity of the samples was 70%.

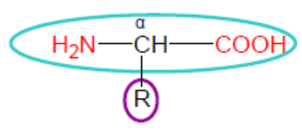
The structure of the PS layer was studied using scanning electron

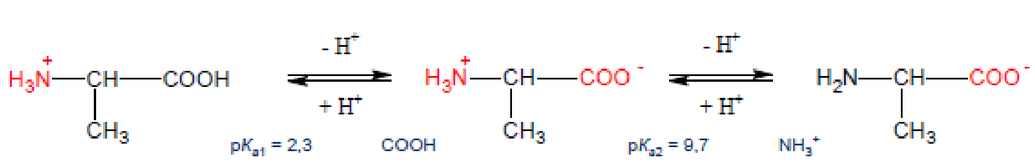


Treatment by solutions of different amino acids



*In aqueous medium with neutral pH and deionized water, the amino acids with non-polar radicals (glycine, alanine, valine, proline), including aromatic one (phenylalanine), are predominantly in the form of a **zwitterion***



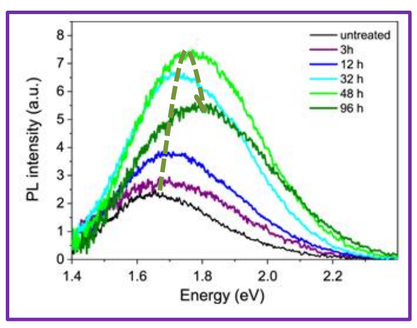


The PS surface was treated with amino acid solutions, then dried in air under room conditions

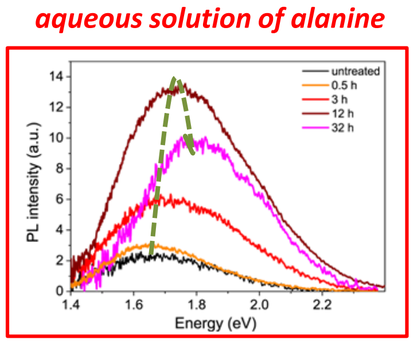
Photoluminescence and IR spectroscopy

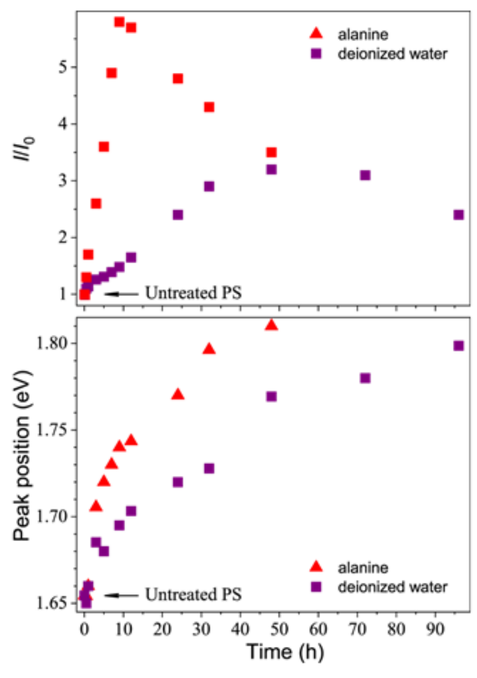
Photoluminescence of PS under exposition to deionized water and aqueous solution of alanine

deionized water

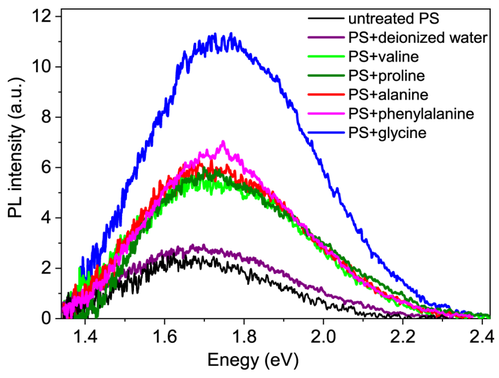


aqueous solution of alanine

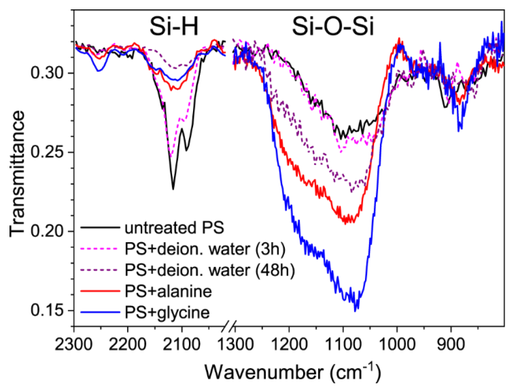




Photoluminescence of PS treated by solutions of different amino acids



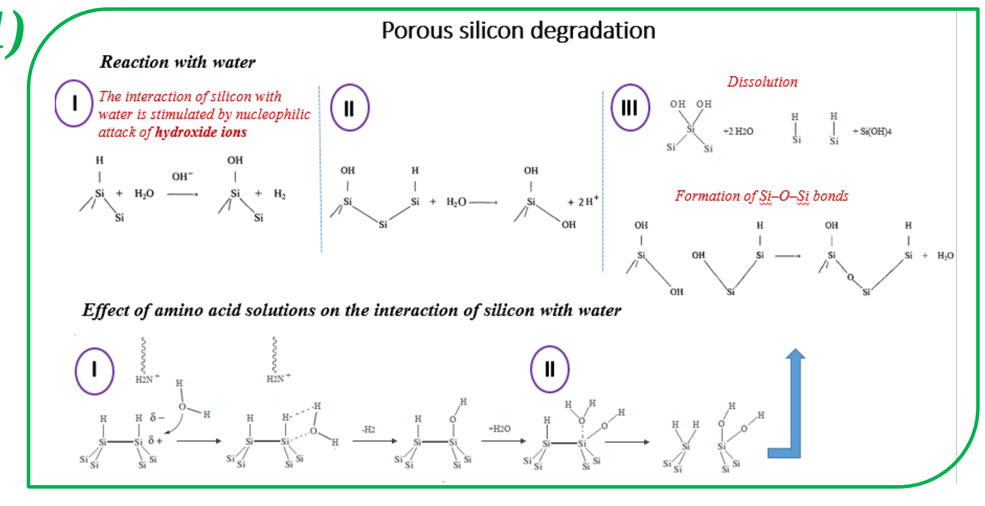
The contribution of silicon oxidation (infrared spectra)



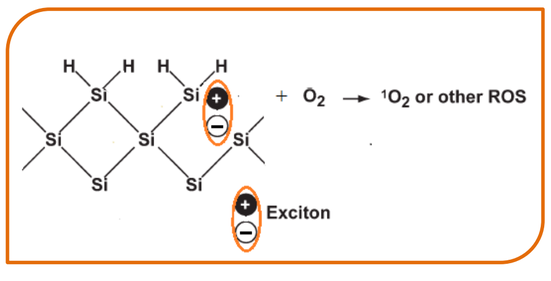
Mechanisms of amino acid effects

1) *The enhanced degradation and oxidation can be related to the ability of the amino groups to be nucleophiles and stimulate the reaction of silicon with water molecules*
2) *The efficient oxidation probably occurs also due to reactive oxygen species (ROS), whose formation is stimulated by PS in solutions of amino acids, especially glycine.*

1)



2)



[1] T. Tieu, M. Alba, R. Elnathan, A. Cifuentes-Rius, N. H. Voelcker, Adv. Therap., **2**, 1800095 (2018).
[2] A. Chaix, E. Cueto-Diaz, A. Delalande, N. Knezevic, P. Midoux, J-O. Durand, C. Pichon and F. Cunin, RSC Adv., **9**, 31895 (2019).
[3] V. Shevchenko, O. Dacenko, V. Makara, S. Golovynskyi, I. Golovynska, Eur. Phys. J. Appl. Phys., **76**, 30401 (2016).

Conclusions

The results obtained in the work allow us to assess the influence of the studied amino acids on the processes of interaction between porous silicon and the aqueous medium and to take it into account when using PS as a drug carrier.