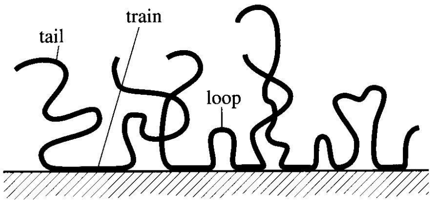
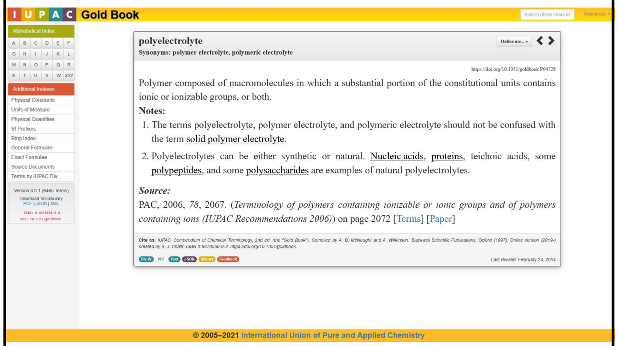
polimeri na površini; adsorpcija polimera




IUPAC Gold Book

polyelectrolyte
Synonyms: polymer electrolyte, polymeric electrolyte

https://doi.org/10.1351/goldbook.P04728

Polymer composed of macromolecules in which a substantial portion of the constitutional units contains ionic or ionizable groups, or both.

Notes:

1. The terms polyelectrolyte, polymer electrolyte, and polymeric electrolyte should not be confused with the term solid polymer electrolyte.
2. Polyelectrolytes can be either synthetic or natural. Nucleic acids, proteins, teichoic acids, some polypeptides, and some polysaccharides are examples of natural polyelectrolytes.

Source:
PAC, 2006, *78*, 2067. (*Terminology of polymers containing ionizable or ionic groups and of polymers containing ions (IUPAC Recommendations 2006)*) on page 2072 [Terms] [Paper]

Cite as: *IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). Online version (2019-) created by S. J. Chalk. ISBN 0-9678550-9-8. https://doi.org/10.1351/goldbook.*

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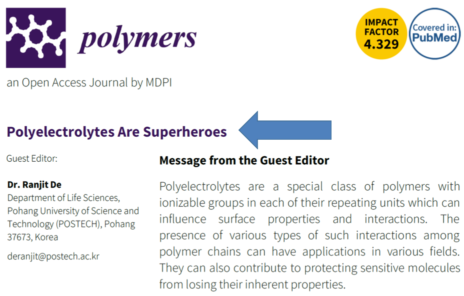
polymers
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Polyelectrolytes Are Superheroes

Guest Editor:

Dr. Ranjit De
Department of Life Sciences, Pohang University of Science and Technology (POSTECH), Pohang 37673, Korea
deranjit@postech.ac.kr

Message from the Guest Editor

Polyelectrolytes are a special class of polymers with ionizable groups in each of their repeating units which can influence surface properties and interactions. The presence of various types of such interactions among polymer chains can have applications in various fields. They can also contribute to protecting sensitive molecules from losing their inherent properties.

polikationi i polianioni; ponašanje na površini

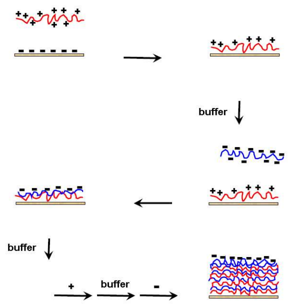
polielektrolitni višesloj (*polyelectrolyte multilayer*)

- nastaju naizmjeničnom adsorpcijom polikationa i polianiona na čvrstu površinu
- najčešća metoda naizmjenično uranjanje u otopinu polielektrolita
- intenzivno istraživan posljednjih petnaestak godina (preko 100 radova godišnje)
- istražuju se uglavnom jaki polielektroliti

polikationi i polianioni; ponašanje na površini

- adsorpcija polielektrolita na kovinskim oksidima
- izmjenično dodavanje pozitivno i negativno nabijenih polielektrolita ⇒ nastajanje višesloja na površini metalnog oksida
- izrastanje višesloja je karakterizirano porastom adsorbirane mase ⇒ metoda praćenja reflektometrija

polyelectrolyte multilayers



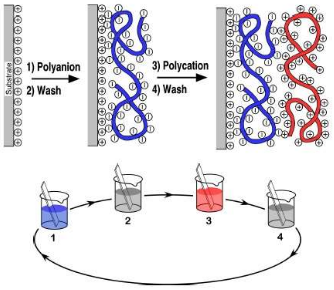


Fig. 1: Formation of PE multilayers

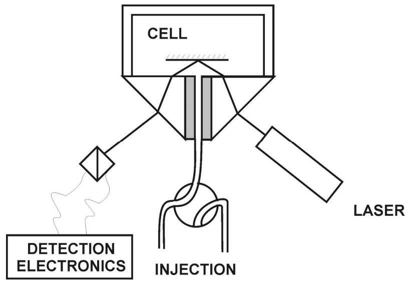
otvorena pitanja

- ponašanje slabih polielektrolita
- mehanizam nastajanja višeslojeva
- polielektrolitni višeslojevi su ravnotežne strukture?
- eksponencijalni vs. linearni rast

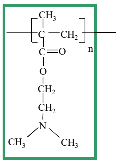
eksperimentalne metode:

- Elipsometrija
- ***<u>Optička reflektometrija</u>***
- Quartz crystal microbalance (QCM)
- Atomic force microscopy (AFM)
- Optical vaweguide lightmode spectroscopy
- Surface plasmon resonance spectroscopy
- Neutron reflectometry
- FTIR-IR, itd, itd...

optička reflektometrija

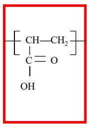


P-AMA Poli(di-metil-Amino-etil-MetAkrilat)



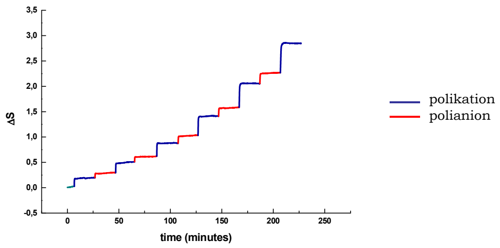
M_w = 20 kg/mol
M_s = 157 g/mol

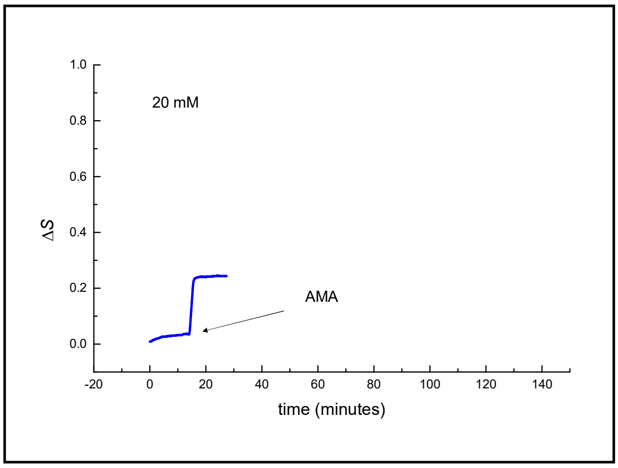
PAA Poli Akrilna kiselina (Acid)

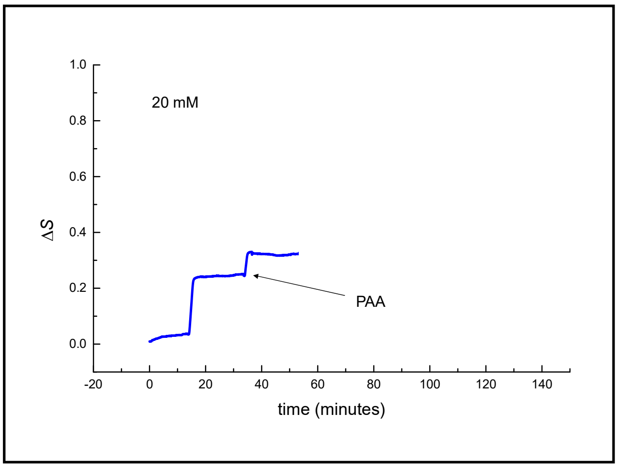


M_w = 12.5 kg/mol
M_s = 72 g/mol

polielektrolitni višeslojevi (*Polyelectrolyte Multilayers*)




20 mM
AMA
ΔS
1.0
0.8
0.6
0.4
0.2
0.0
-20
0
20
40
60
80
100
120
140
time (minutes)


20 mM
PAA
ΔS
1.0
0.8
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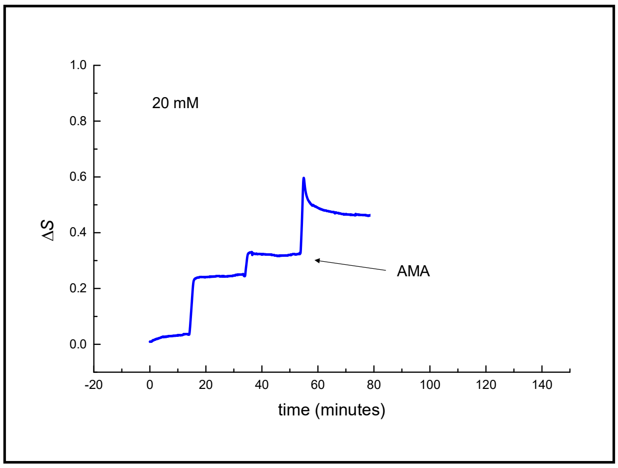
time (minutes)


20 mM
AMA
ΔS
1.0
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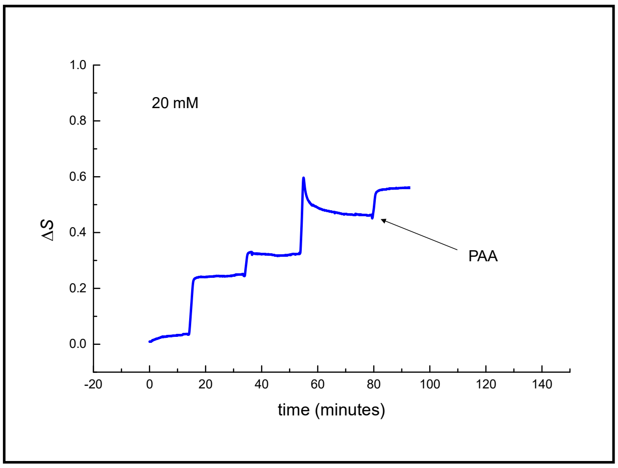
time (minutes)


20 mM
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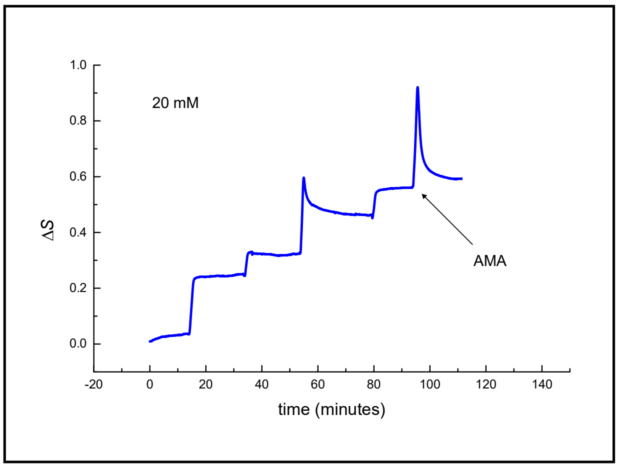
time (minutes)


20 mM
AMA
ΔS
1.0
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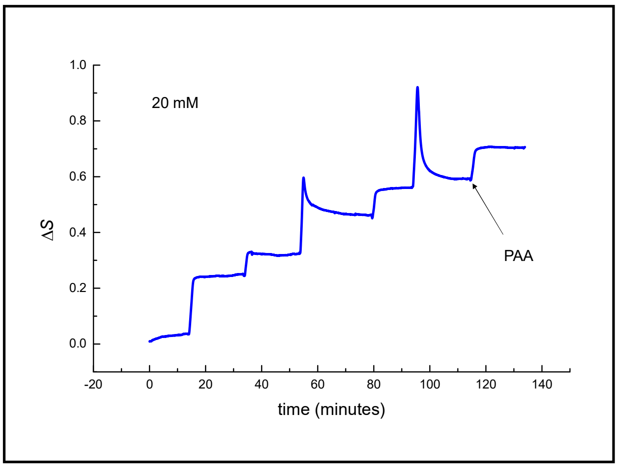
120
140
time (minutes)


20 mM
PAA
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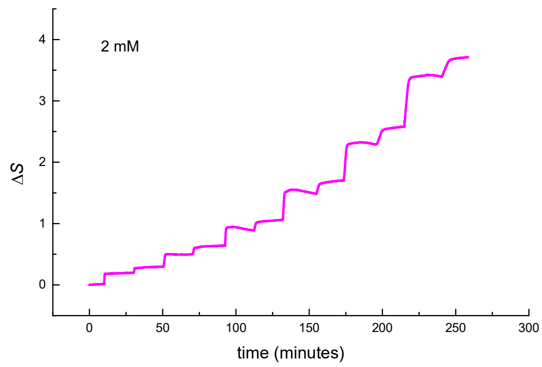
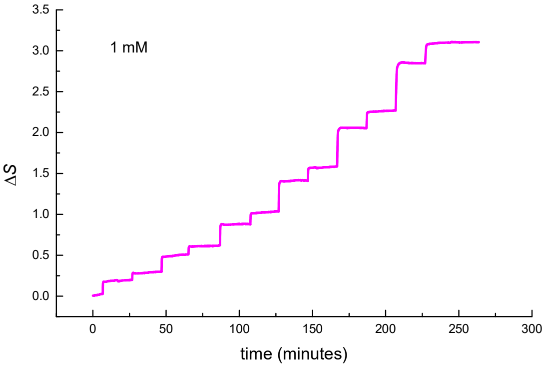
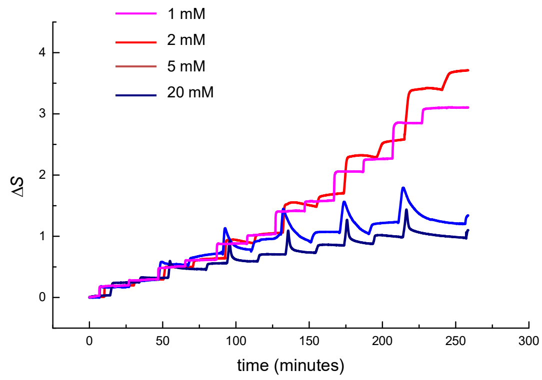
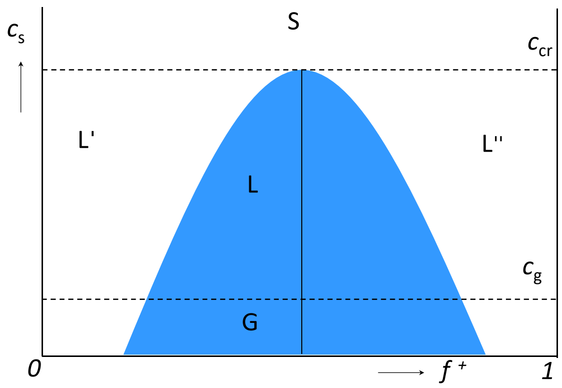
time (minutes)



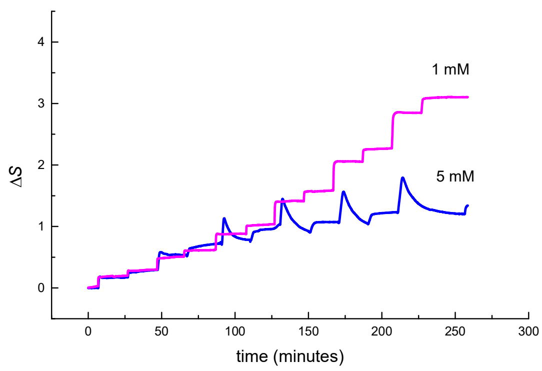






AFM mjerenja

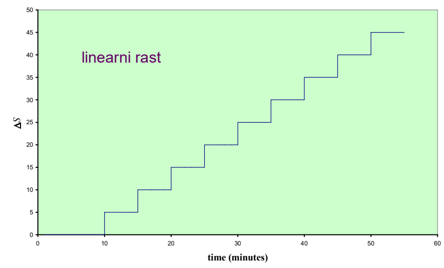
- usporedba između uzoraka pripremljenih pri 1 mM i 5 mM
- contact mode AFM



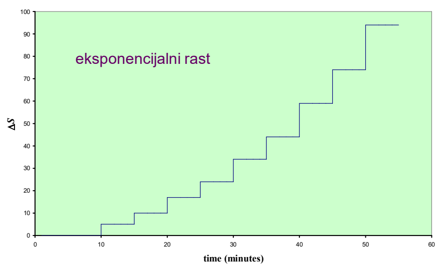
otvorena pitanja

- ponašanje slabih polielektrolita
- mehanizam nastajanja višeslojeva
- polielektrolitni višeslojevi su ravnotežne strukture?
- eksponencijalni vs. linearni rast

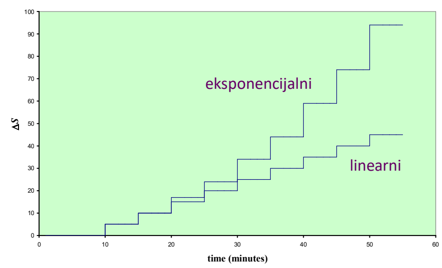
eksponencijalni vs. linearni rast



eksponencijalni vs. linearni rast



eksponencijalni vs. linearni rast

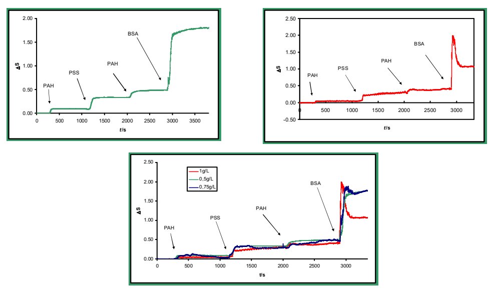


eksponencijalni vs. linearni rast

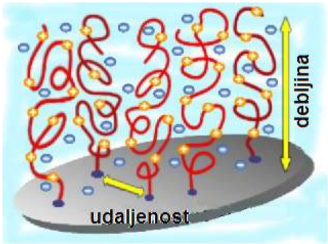
Faktori koji utječu na tip rasta:

- kemijska priroda polielektrolitnog para
- vrsta dodanog elektrolita
- ionska jakost
- temperatura
- metoda priprave

adsorpcija BSA na prethodno formirani polielektrolitni višesloj



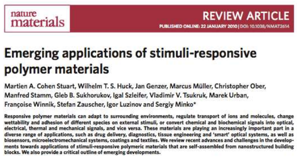
polielektrolitne "četke"
(*Polyelectrolyte Brushes*)



polyelectrolyte multilayers - applications

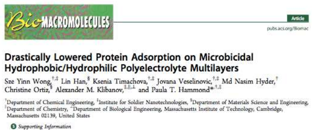
Biomedicine and pharmaceutical industry

- Surface modification (thickness, charge, etc…)
- Drug delivery
- Formation of stimuli responsive systems (e.g. mechanical, temperature, pH)
- Surfaces with antibacterial properties


nature materials REVIEW ARTICLE

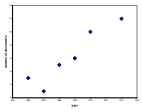
Emerging applications of stimuli-responsive polymer materials

Martien A. Cohen Stuart, Wilhelm T. S. Huck, Jan Genzer, Marcus Müller, Christopher Ober, Manfred Stamm, Gleb B. Sukhorukov, Igal Szleifer, Vladimir V. Tsukruk, Marek Urban, Françoise Winnik, Stefan Zauscher, Igor Luzinov and Sergiy Minko*


Biomacromolecules Article

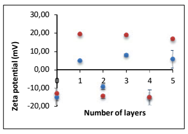
Drastically Lowered Protein Adsorption on Microbicidal Hydrophobic/Hydrophilic Polyelectrolyte Multilayers

Sze Yinn Wong, Lin Han, Ksenia Timachova, Jovana Veselinovic, Md Nasim Hyder, Christine Ortiz, Alexander M. Klibanov, and Paula T. Hammond*

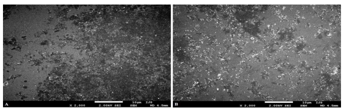


number of publication per year: antimicrobial properties of polyelectrolyte multilayers

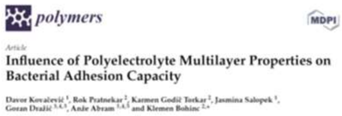
adhesion of bacteria on polyelectrolyte multilayers



PAH/PSS multilayer



adhesion of bacteria *Pseudomonas aeruginosa* on PAH/PSS multilayer (SEM).
(A) five layers with positive terminating layer (PAH)
(B) six layers with negative terminating layer (PSS)

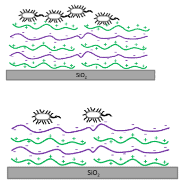

polymers MDPI

Article

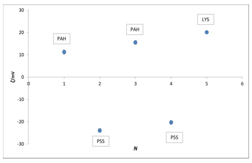
Influence of Polyelectrolyte Multilayer Properties on Bacterial Adhesion Capacity

Davor Kovačević [1], Rok Pratnekar [2], Karmen Godič Torkar [2], Jasmina Salopek [1], Goran Dražić [3,4,5], Anže Abram [3,4,5] and Klemen Bohinc [2,*]

	PAH as terminating layer (5 layers)	PSS as terminating layer (6 layers)
Fraction of the multilayer surface covered with P. aeruginosa	20.4 % ± 4.8 %	9.0 % ± 3.1 %
Contact angle	48.9° ± 2.5°	46.9° ± 5.0°
Roughness	0.017 μm ± 0.004 μm	0.019 μm ± 0.006 μm

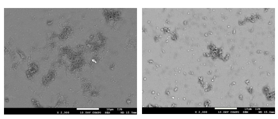


adhesion of bacteria on protein-terminating polyelectrolyte multilayers

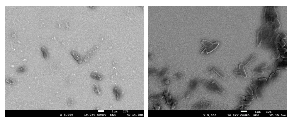


	Lysozyme as terminating layer (5 layers)	BSA as terminating layer (5 layers)	Glucanase as terminating layer (5 layers)
Contact angle	63.2° ± 0.1°	63.2° ± 6.0°	66.7° ± 9.4°
Roughness/μm	0.120 ± 0.00	0.072 ± 0.00	0.018 ± 0.006
z-potential/mV	20.10 ± 0.35	7.24 ± 0.74	-11.77 ± 0.40

adhesion of bacteria on protein-terminating polyelectrolyte multilayers

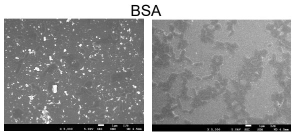


lysozyme



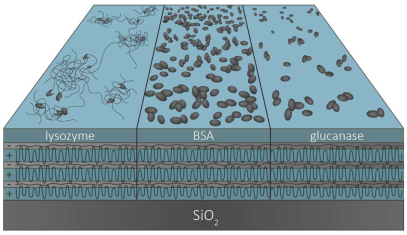
BSA

Two types of bacteria:
- *Pseudomonas aeruginosa* - left
- *Escherichia Coli* - right

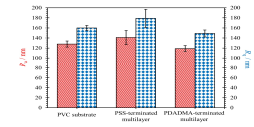


glucanase

adhesion of bacteria on protein-terminating polyelectrolyte multilayers



bacterial adhesion capacity of uropathogenic *Escherichia coli* to polyelectrolyte multilayer coated urinary catheter surface



Model catheter surface:
PVC surface

Key surface properties:
charge
hydrophobicity
roughness

Table 1. Quantitative measurements of the local average surface roughness (R_a) and root-mean-square (RMS) surface roughness (R_q) made on the PVC catheter sample and the same material covered with PSS/PDADMA films.

Sample	R_a/nm	R_q/nm
PVC substrate	128 ± 6	160 ± 5
PVC substrate coated with PSS-terminated multilayer	141 ± 14	179 ± 18
PVC substrate coated with PDADMA-terminated multilayer	119 ± 6	149 ± 7

Table 2. Zeta potential of uncoated and coated PVC surfaces at pH ≈ 7.7.

Sample	(ζ ± SE)/mV
PVC substrate	+15.84 ± 2.0
PVC substrate coated with PSS-terminated multilayer	−63.25 ± 0.35
PVC substrate coated with PDADMA-terminated multilayer	+4.19 ± 0.25

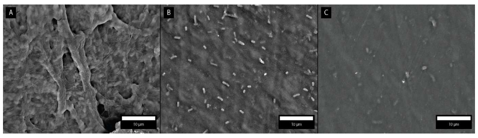
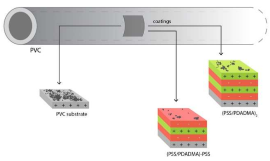


Table 3. Number of adhered bacteria per 1700 µm².

	PVC Substrate	PVC Substrate Coated with PDADMA-Terminated Multilayer	PVC Substrate Coated with PSS-Terminated Multilayer
Number of adhered bacteria per 1700 µm²	Biofilm formation	50 ± 12	31 ± 17



K. Bohinc, L. Kukić, R. Štukelj, AM. Zore, A. Abram, T. Klačić, D. Kovačević, Coatings, 11 (2021) 630.

šuplje sfere