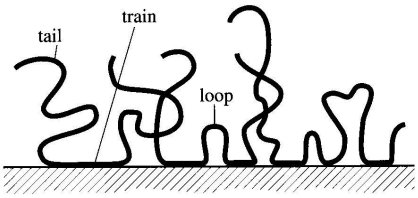
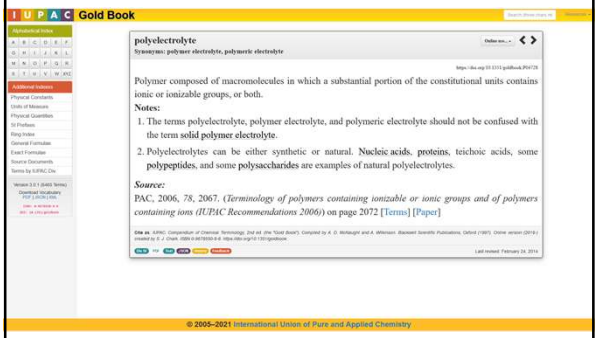
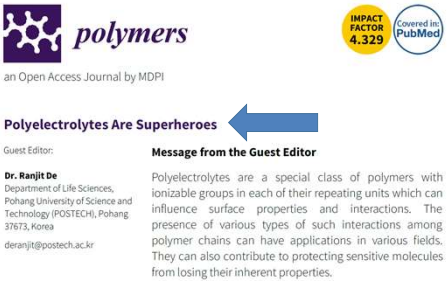
polimeri na površini; adsorpcija polimera







polikationi i polianioni; ponašanje na površini

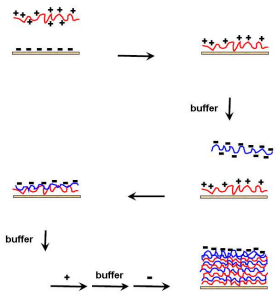
polielektrolitni višesloj (*polyelectrolyte multilayer*)

- 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



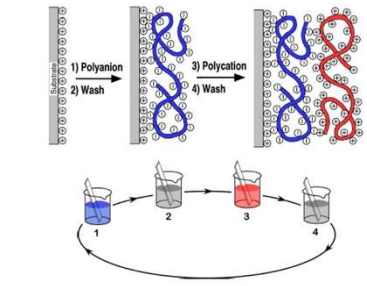


Fig. 1: Formation of PE multilayers

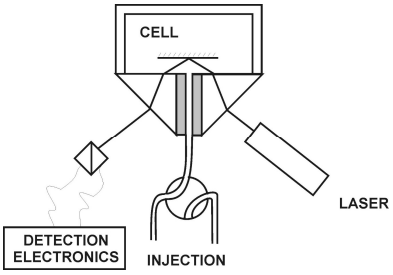
otvorena pitanja

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

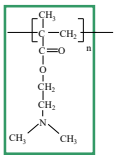
eksperimentalne metode:

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

optička reflektometrija

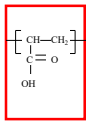


P-AMA Poli(di-metil-**A**mino-etil-**M**et**A**krilat)



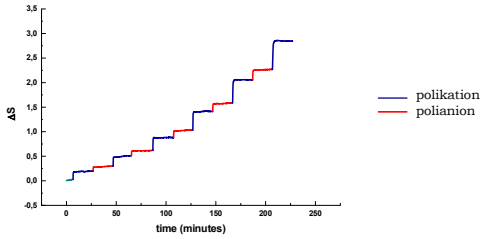
M_w = 20 kg/mol
M_s = 157 g/mol

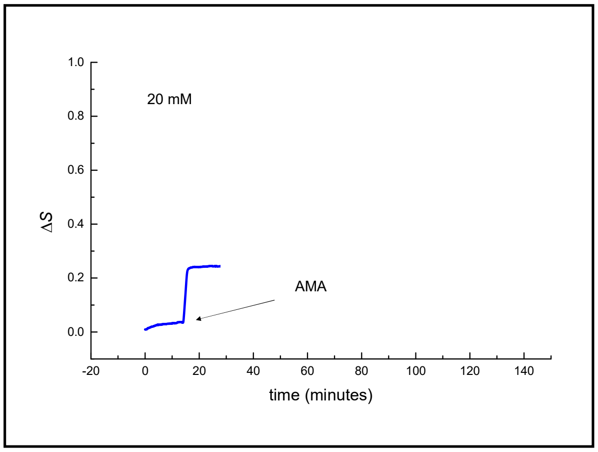
PAA **P**oli **A**krilna kiselina (**A**cid)

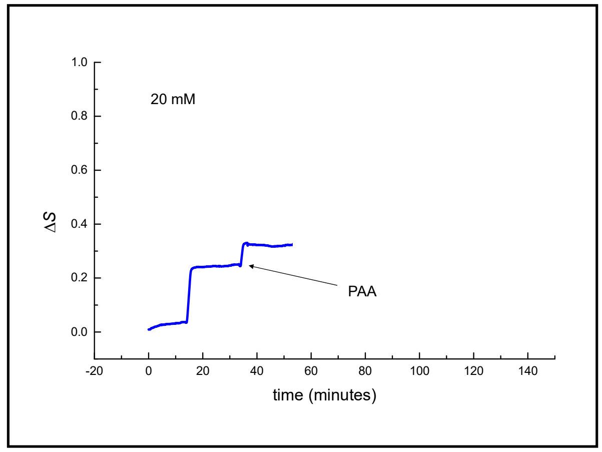


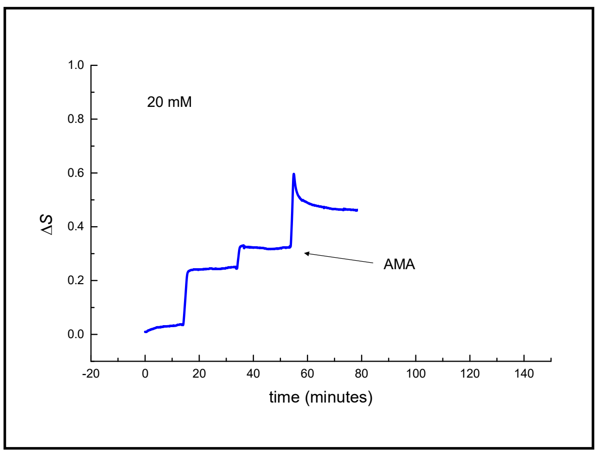
M_w = 12.5 kg/mol
M_s = 72 g/mol

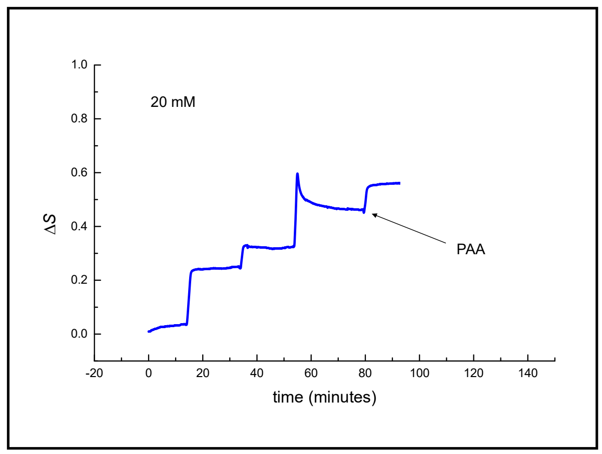
polielektrolitni višeslojevi (*Polyelectrolyte Multilayers*)

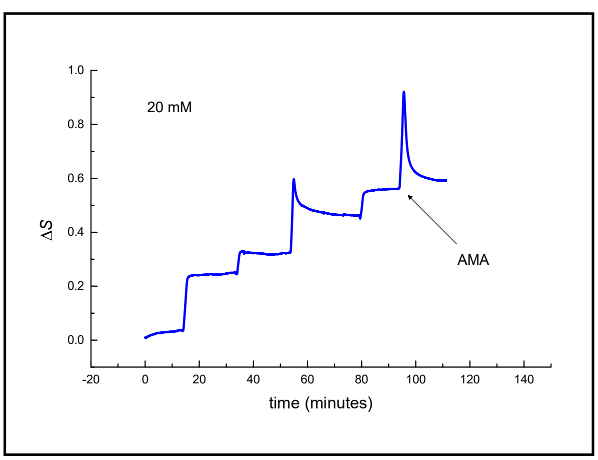


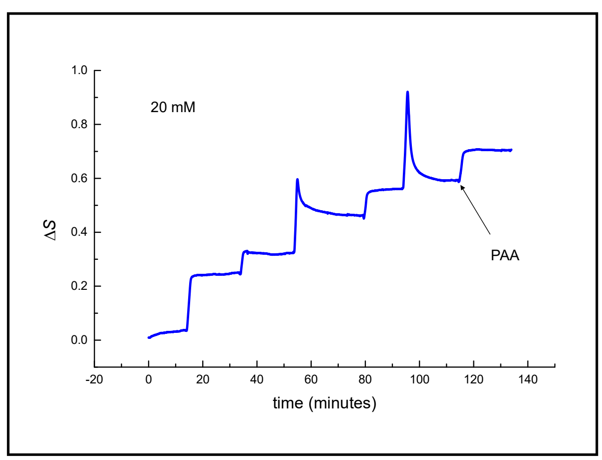

20 mM
AMA
ΔS
time (minutes)

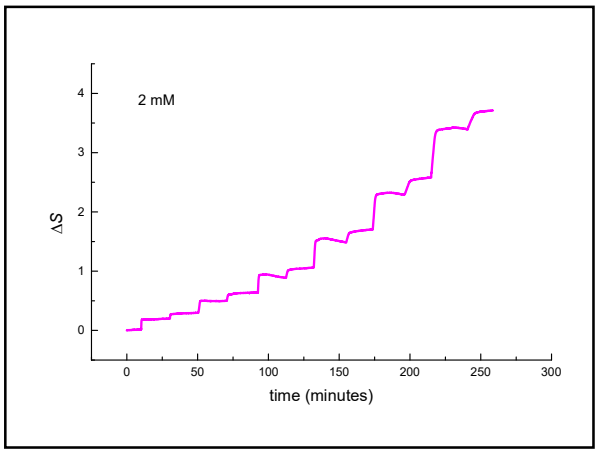

20 mM
PAA
ΔS
time (minutes)

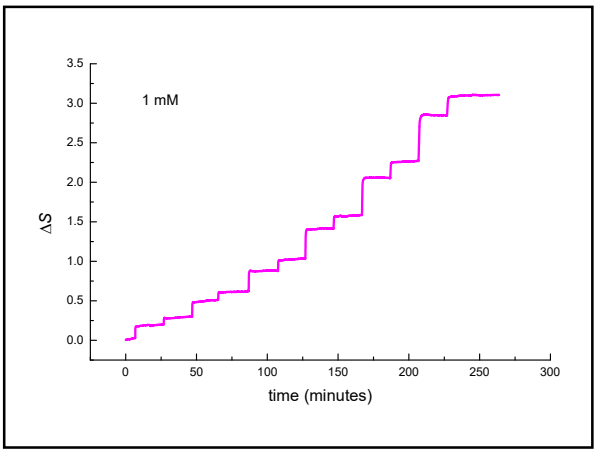

20 mM
AMA
ΔS
time (minutes)

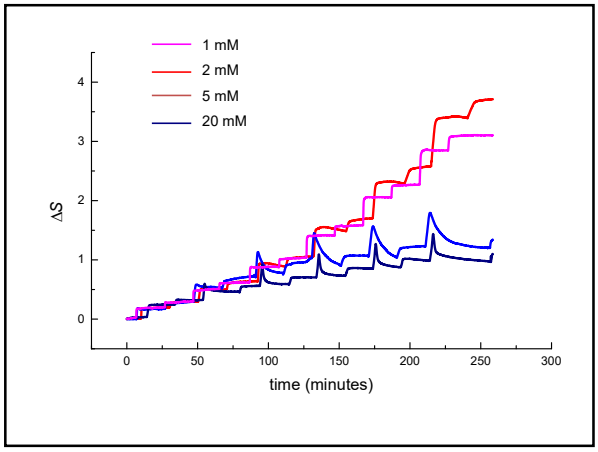

20 mM
PAA
ΔS
time (minutes)

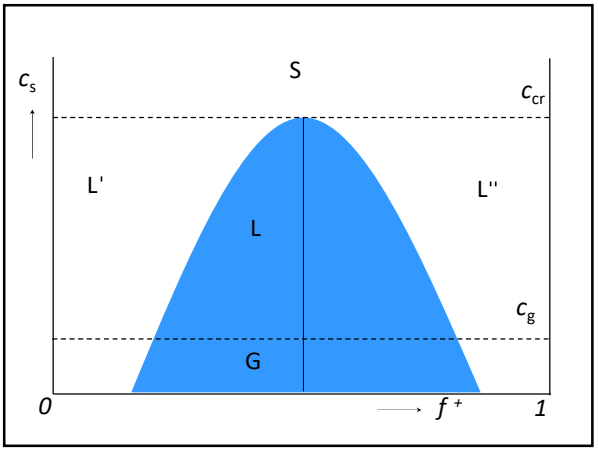

20 mM
AMA
ΔS
time (minutes)


20 mM
PAA
ΔS
time (minutes)



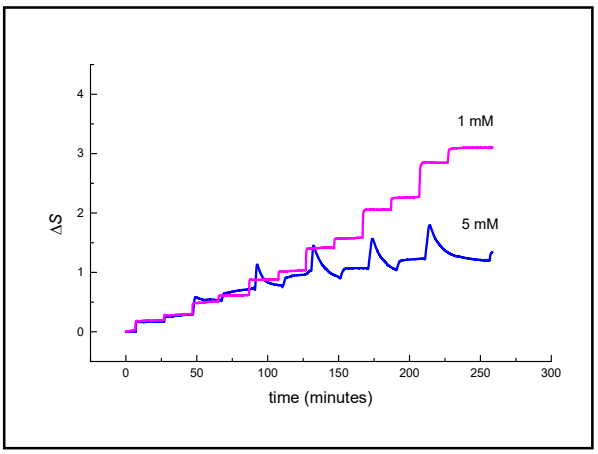






AFM mjerenja

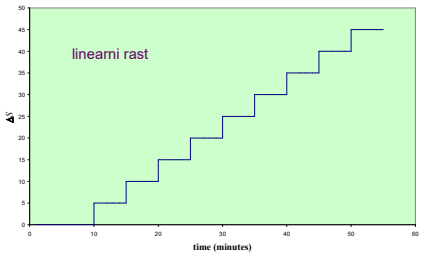
- usporedba između uzoraka pripremljenih pri 1 mM i 5 mM
- contact mode AFM



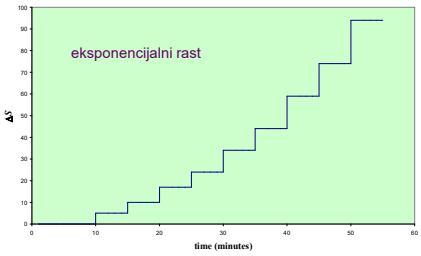
otvorena pitanja

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

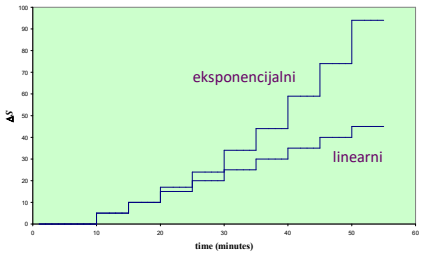
eksponencijalni vs. linearni rast



eksponencijalni vs. linearni rast



eksponencijalni vs. linearni rast

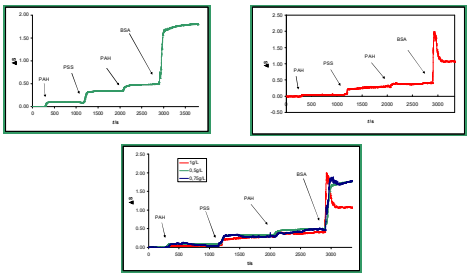


eksponencijalni vs. linearni rast

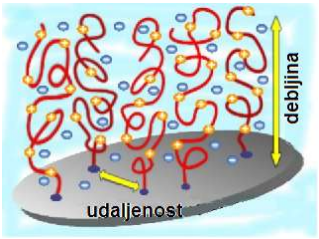
Faktori koji utječu na tip rasta:

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

adsorpcija BSA na prethodno formirani polielektrolitni višesloj



polielektrolitne "četke" (*Polyelectrolyte Brushes*)

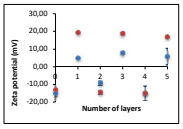


polyelectrolyte multilayers - applications

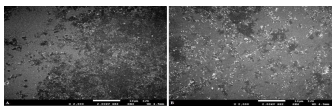
Biomedicine and pharmaceutical industry

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

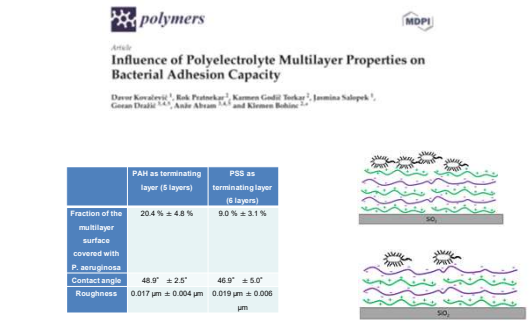
adhesion of bacteria on polyelectrolyte multilayers



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)

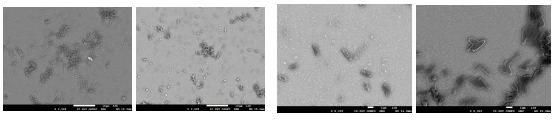


	PAH as terminating layer (5 layers)	PSS as terminating layer (6 layers)
Fraction of the multilayer surface covered with P. aeruginosa	20.4 % ± 4.8 %	9.0 % ± 3.1 %
Contact angle	48.9° ± 2.5°	46.9° ± 5.0°
Roughness	0.017 µm ± 0.004 µm	0.019 µm ± 0.006 µm

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

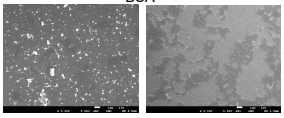
adhesion of bacteria on protein-terminating polyelectrolyte multilayers



lysozyme

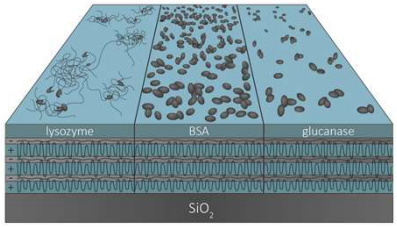
BSA

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

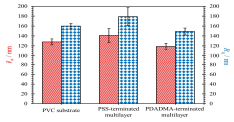


glucanase

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 = 7.3.

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

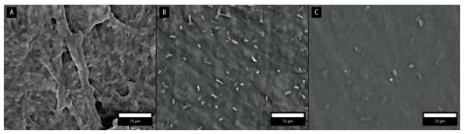
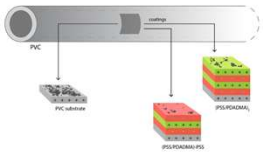


Table 3. Number of adhered bacteria per 1700 μm².

	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.

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