Nanostructured Bioactive Polymeric Layers for Trapping DNA and Proteins

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NANOSPAIN 2017

San Sebastian, Spain, March, 7-10, 2017

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-Anionic copolymer and types of supports

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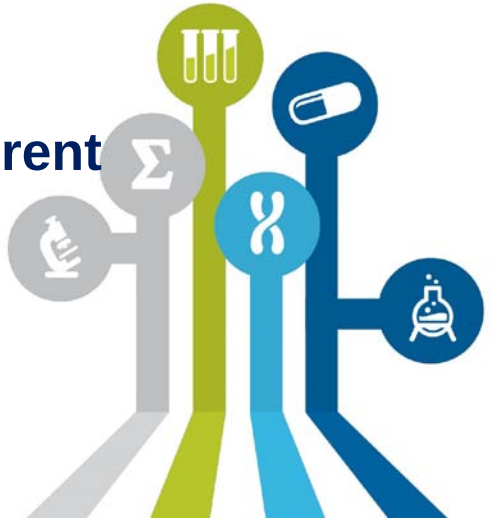
-Nanostructured layers of anionic polymer over different substrates

-AFM study of protein trapping

Summary



Introduction

Bio**MACROMOLECULES** sensing as

electrical signal

Introduction

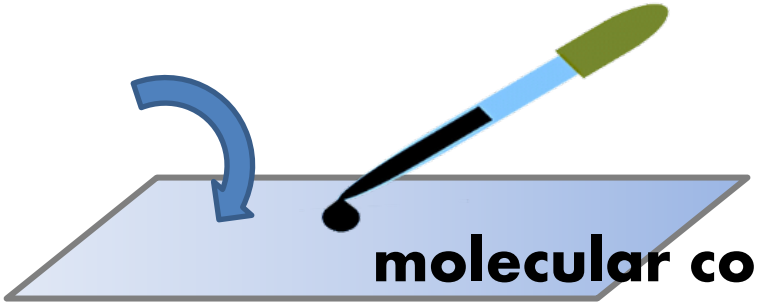
➢ **approach:**

Engineering the nano-structured layer of bioactive polymer over highly piezoresistive conductive layers

Concept of sensing

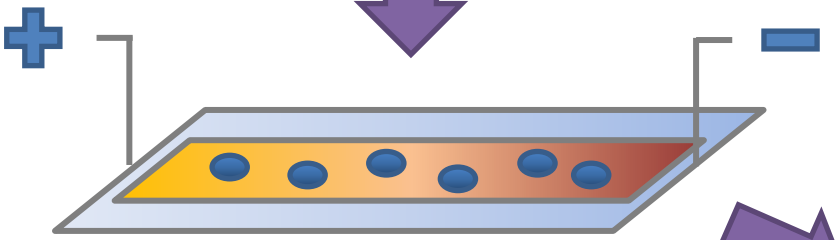
electrical response

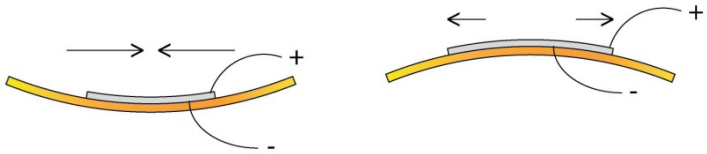
bioactive copolymer



molecular conductor

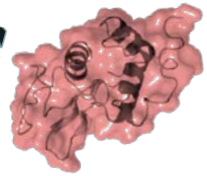
(gauge factor = 10)
TRC =-0.035%/deg

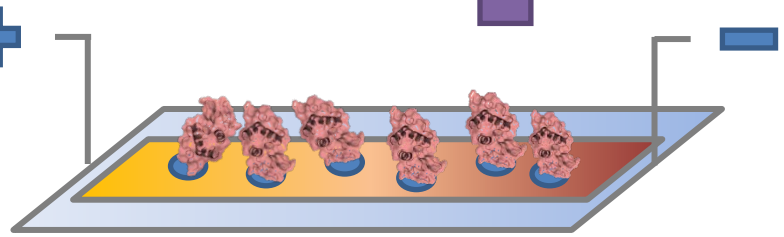




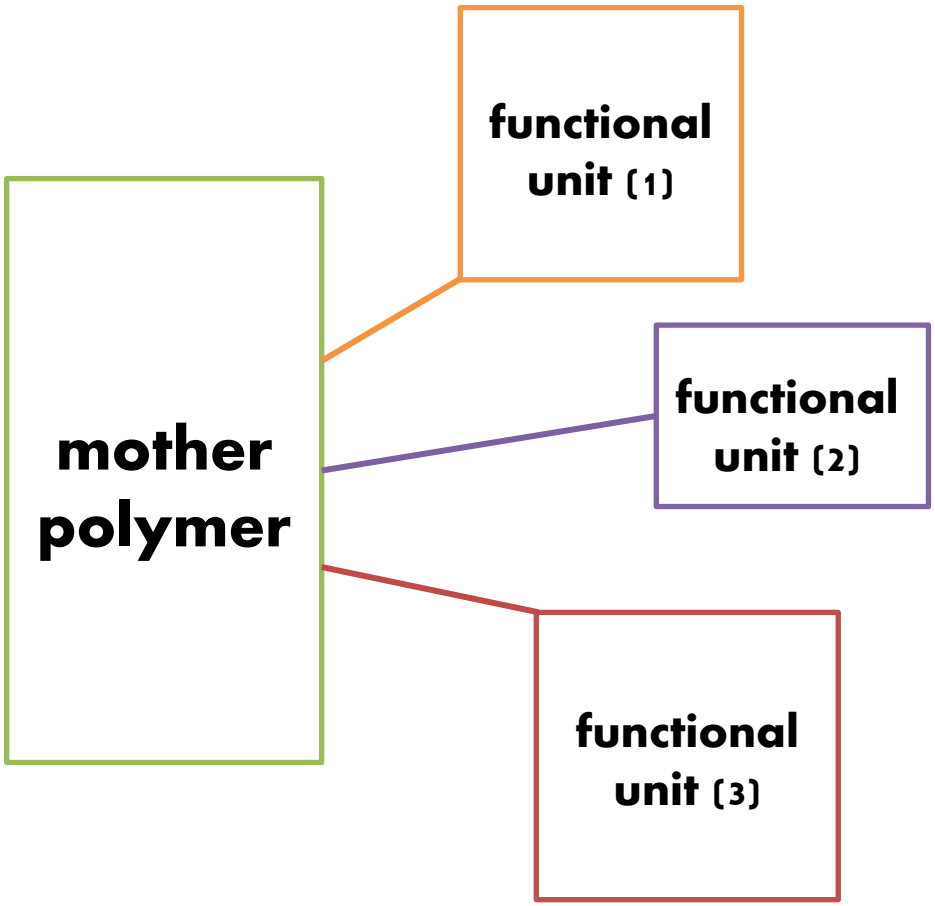
deformation

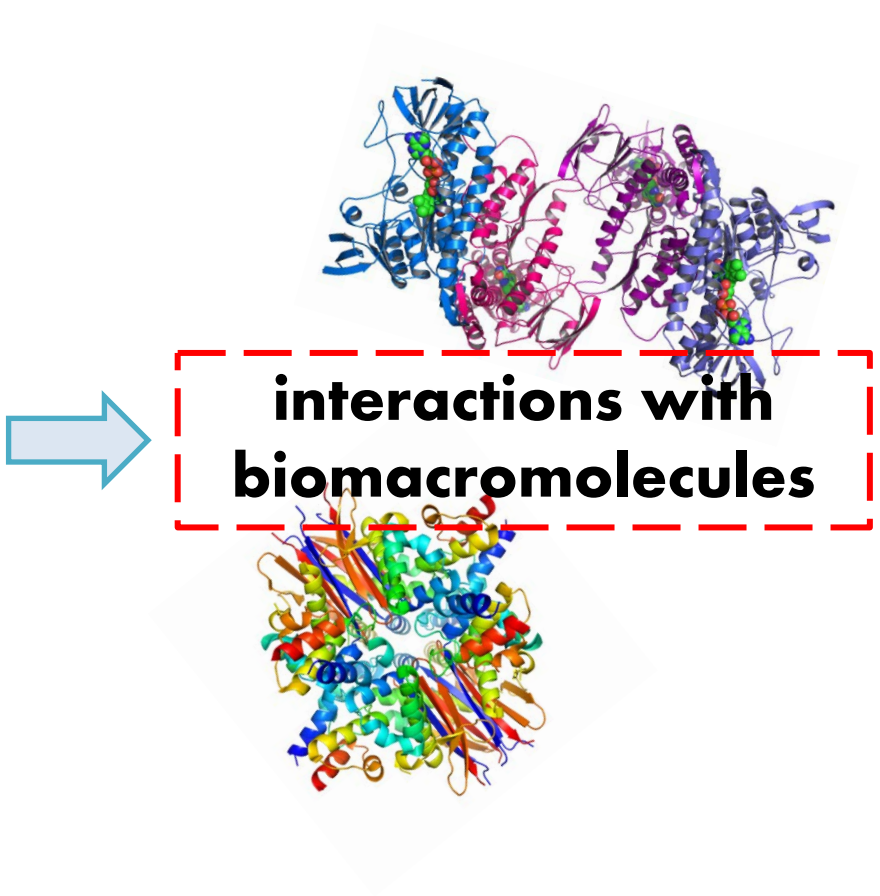
BioMACROMOLECULES



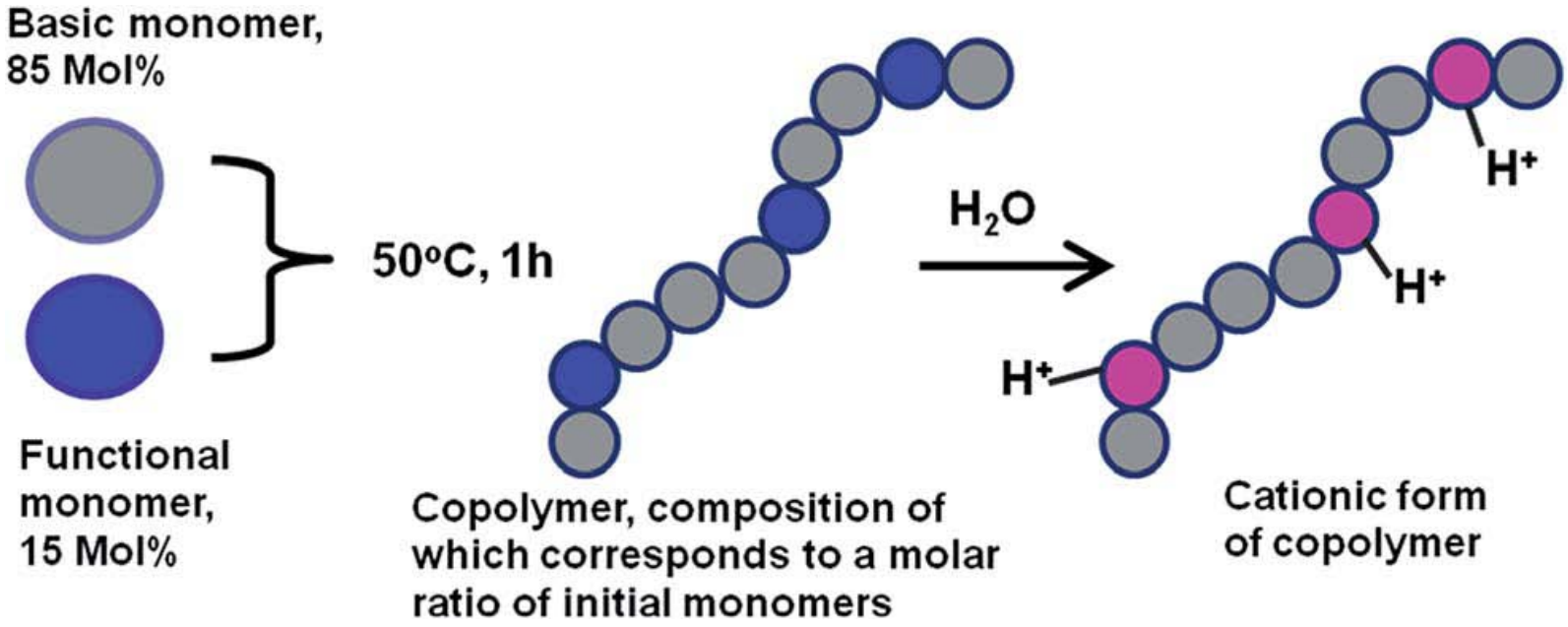


What is bioactive polymer?





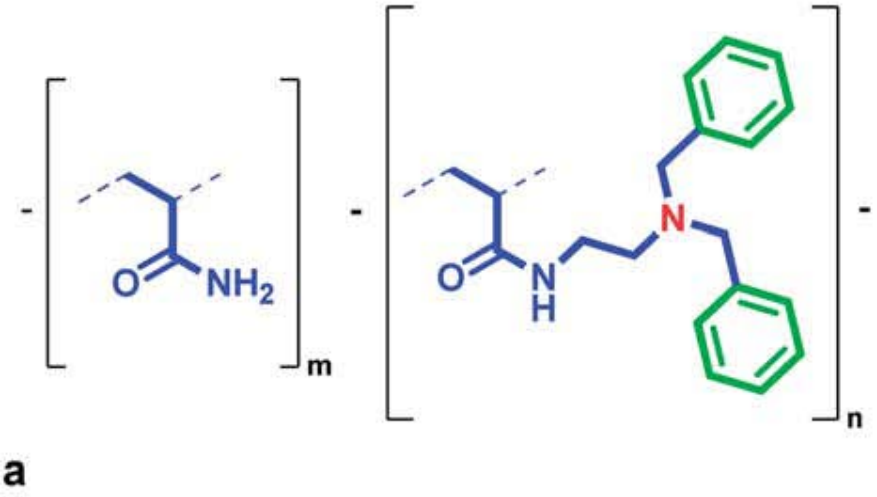
Concept of preparing cationic (anionic) polymers with desired DNA (protein) trapping properties



a functional group approach in combination with a free-radical copolymerization process

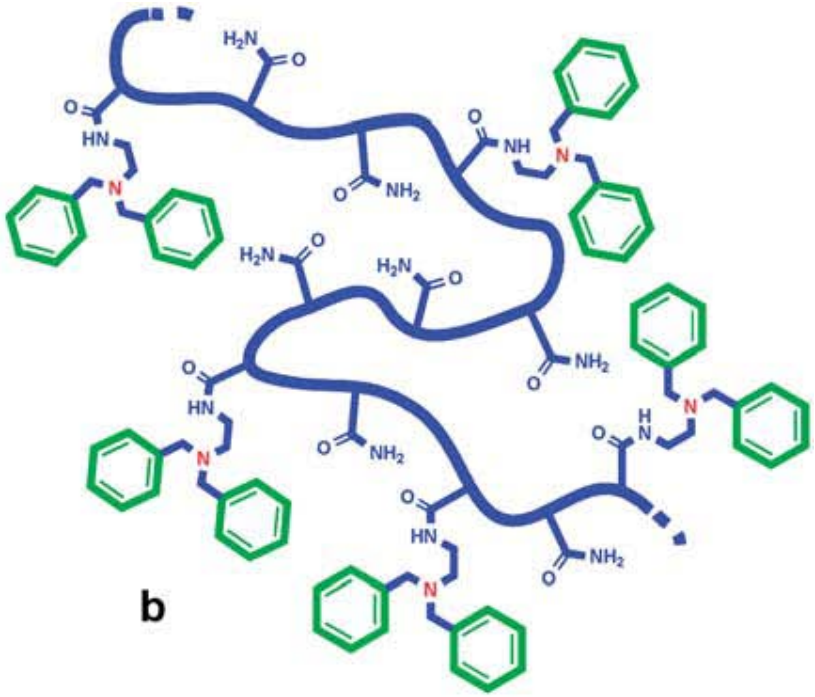
Results:

Bioactive cationic copolymer:
N-(2-dibenzylamino-ethyl)-acrylamide



a

m, n = 0, 1, 2 ...

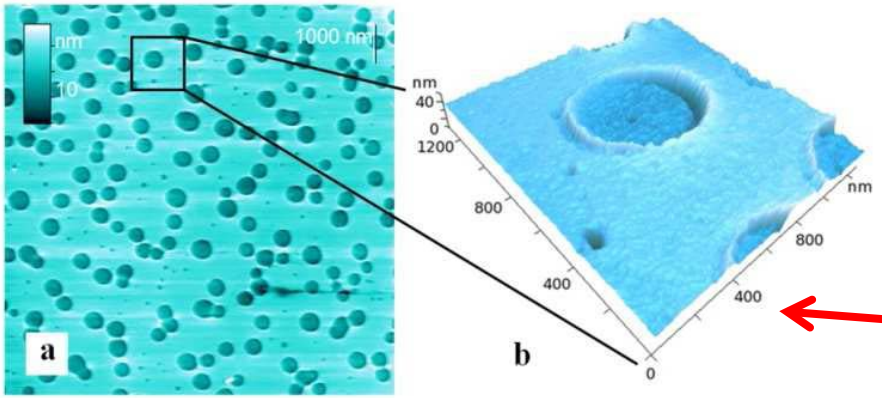


b

O. V. Sinitsyna, N. K. Davydova, V. N. Sergeev and E. E. Laukhina: "*Nanostructured films by the self-assembly of bioactive copolymer." RSC Adv*. 2014, **4**, 55565

O. V. Sinitsyna, N. K. Davydova, V. N. Sergeev and E. E. Laukhina Towards DNA sensing polymers: interaction between acrylamide/3-(N,Ndimethylaminopropyl)-acrylamide and DNA phagel at various N/P ratios, RSC Adv., 2016, **6**, 58212

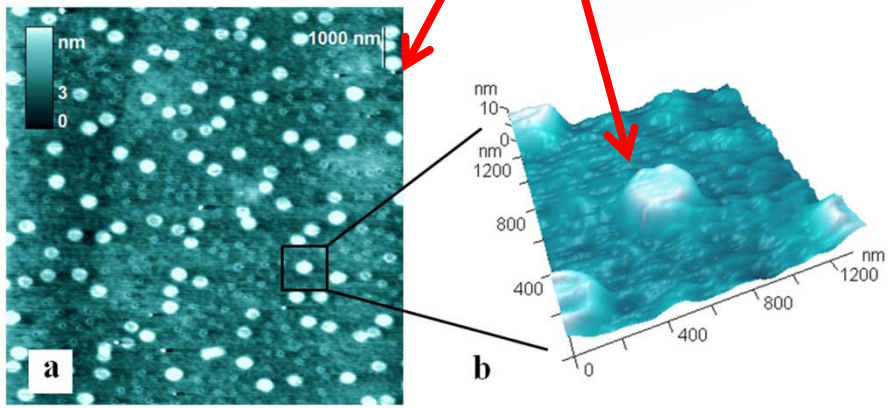
Results:



The typical AFM images of the surface of the film over a mica crystal:
original film

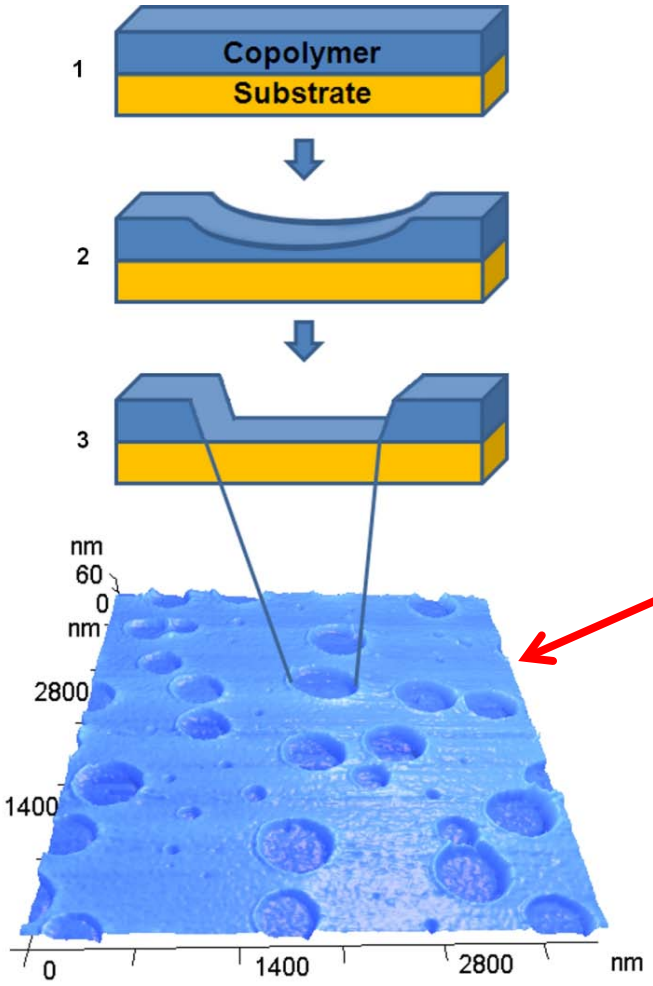
with trapped DNA molecules

0.01 mg/ml water solution of λ-phage DNA (Fermentas)



Results:

Mechanism of the cavity formation



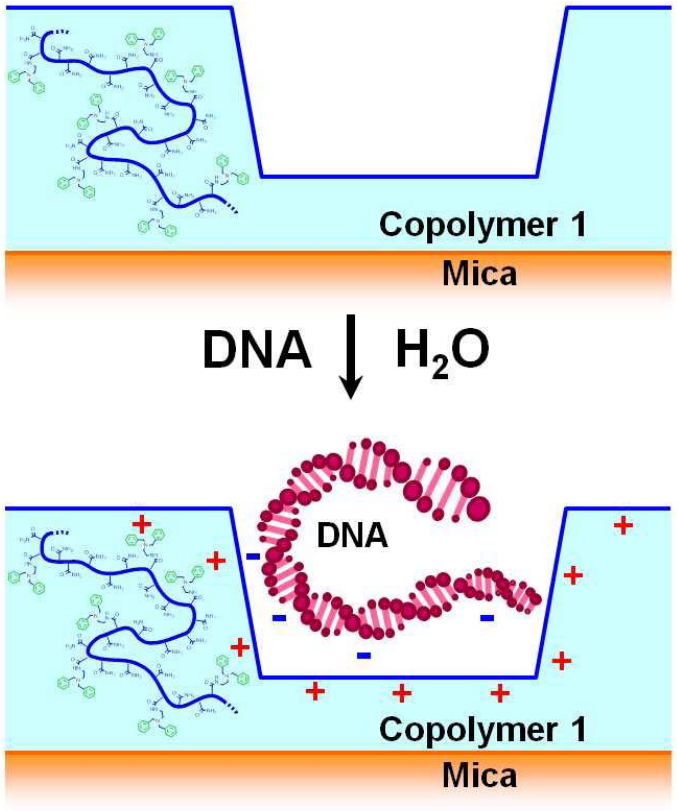
If nucleation of holes is initiated by a spontaneous (spinodal) process

high regularity of cavities will be observed in the AFM image

In this case dispersion forces are at play; this results in the unstable form of a thin film with a very high surface-to-volume ratio which in turn causes the hole to grow

Results:

Mechanism of DNA trapping by the nanocavities of the film based on cationic copolymer



1. The film molecules contain tertiary amine groups that are protonated in water solutions.

2. the surface of the film is positively charged when a DNA water solution comes into contact with it.

3. Film is able to trap negative charged DNA molecules using electrostatic interactions.

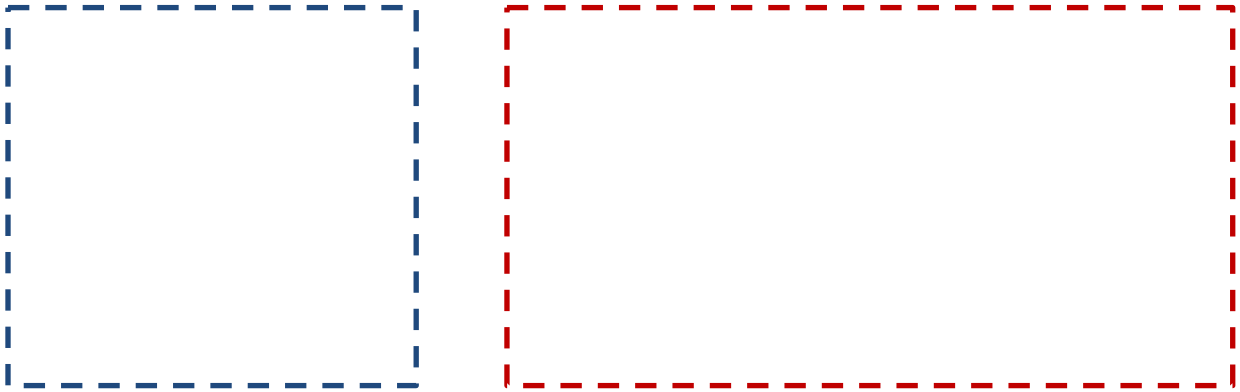
The cavities are the most preferable sites for DNA binding !

their surface geometry provides a greatest number of electrostatic interactions !

Results:

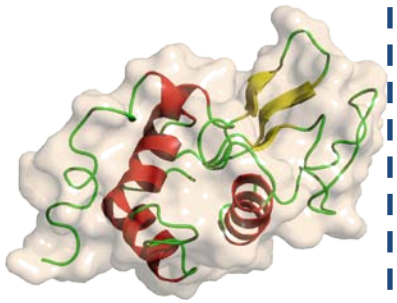
Bioactive anionic copolymer

in water solution



π-π interactions

positively charged proteins



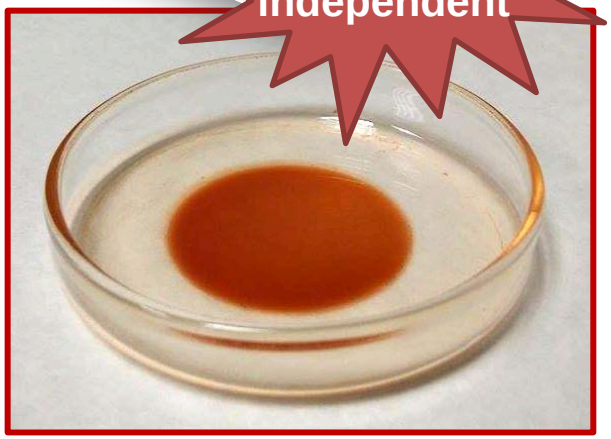
Results:

Film preparation

substrates:

gold

silica



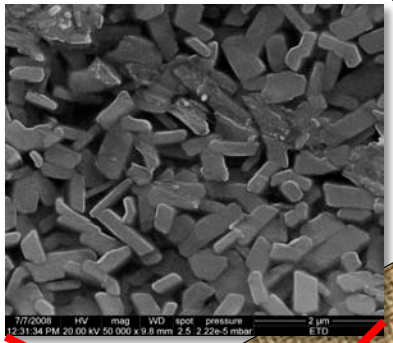
Organic bi layer conducting film

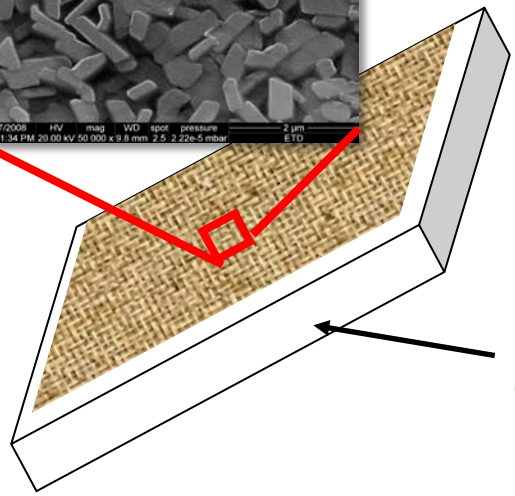
What is BL conducting film?

molecular conductor*

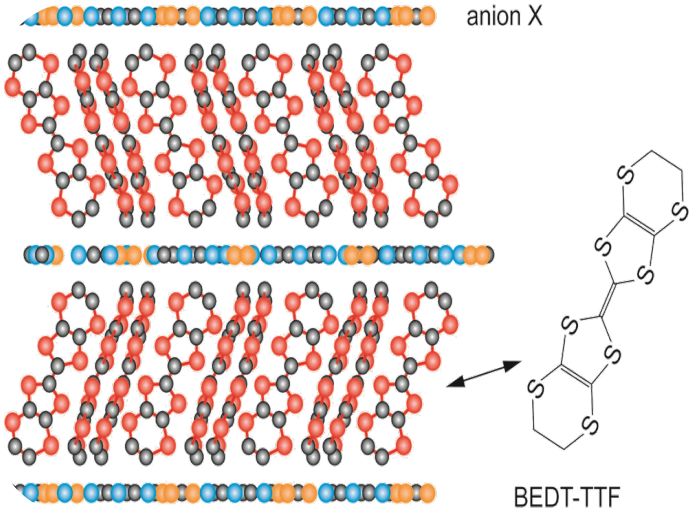
α-(BEDT-TTF)$_2$I$_3$

The layer of a **BEDT-TTF**-based organic molecular conductor



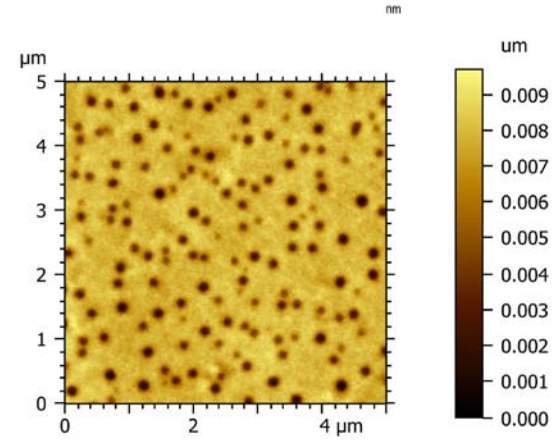


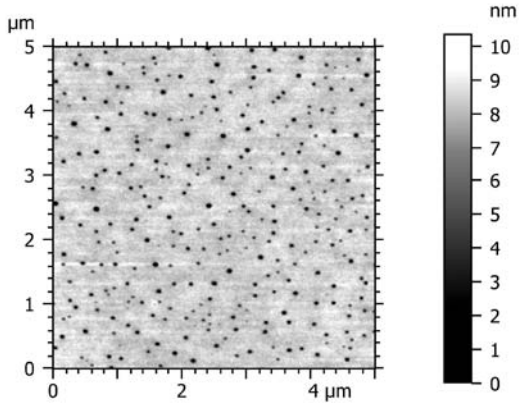
Polycarbonate film (5-30 μm)

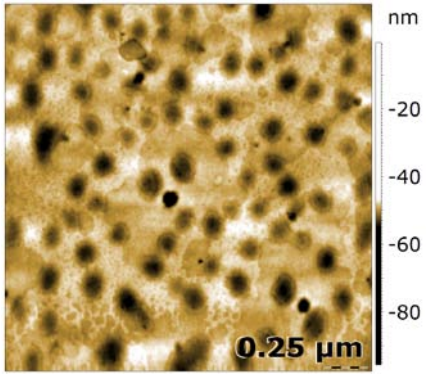


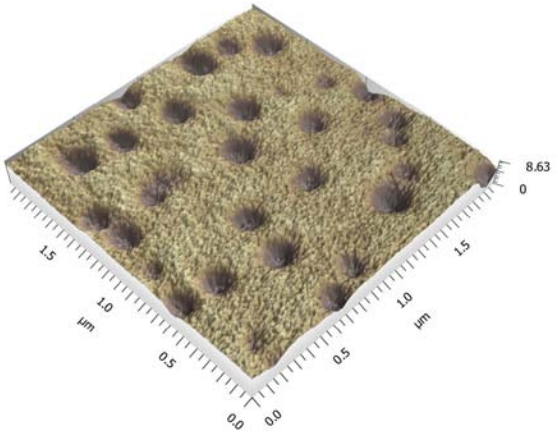
Results:

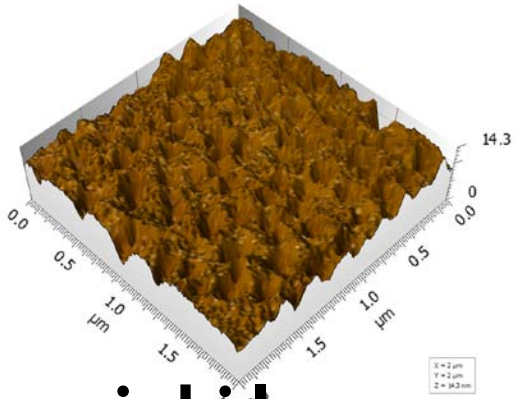
AFM images of the anionic polymer over different substrates









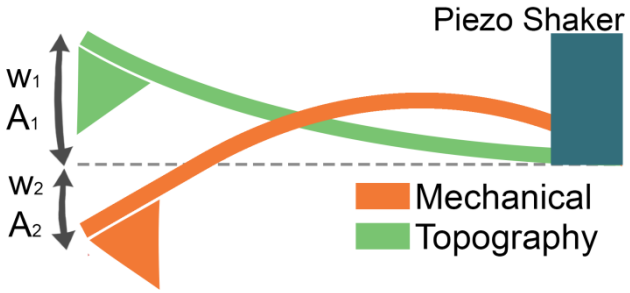


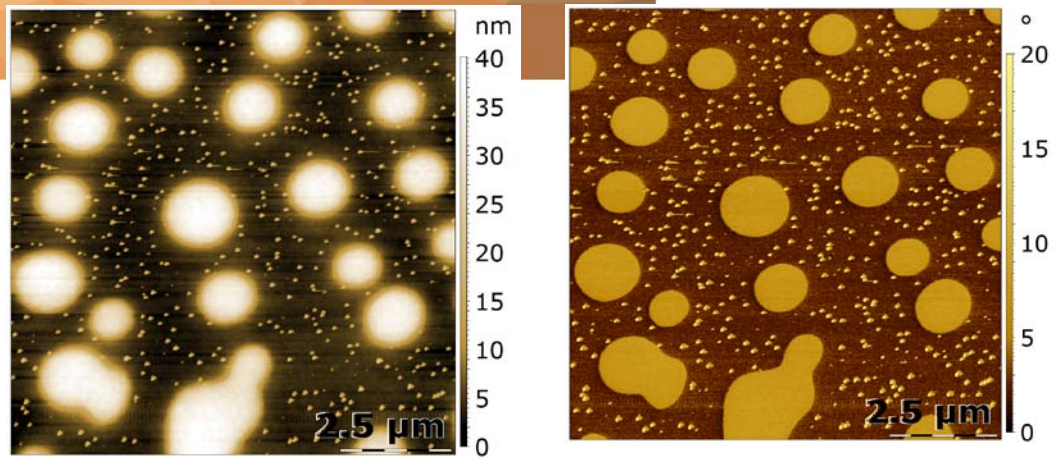
gold

silica

Organic bi layer conducting film

Bimodal frequency-modulated atomic force microscopy

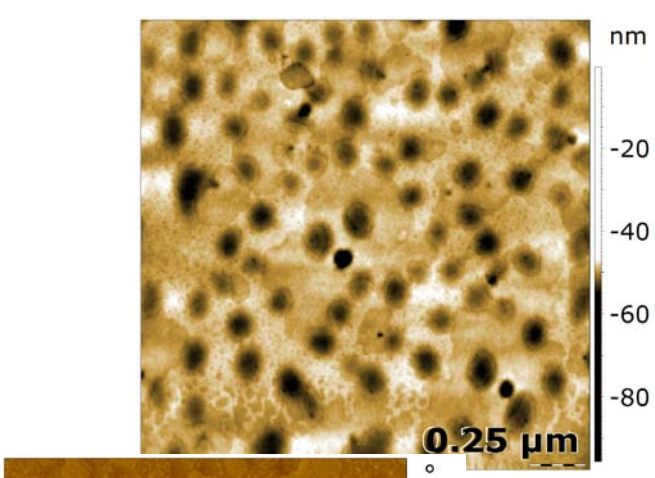


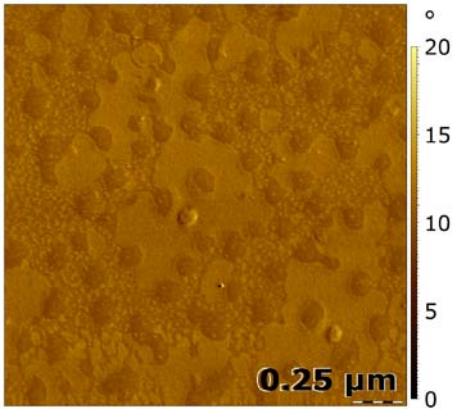


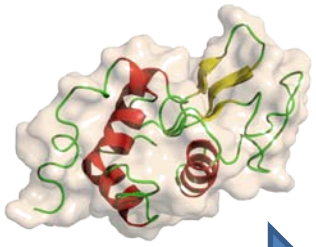
Reference Sample of two different polymers

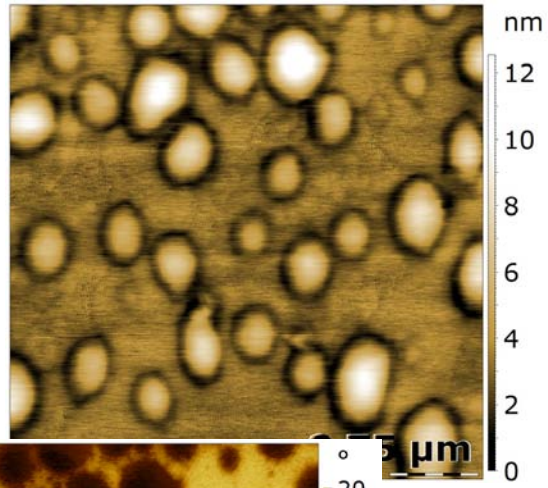
Results:

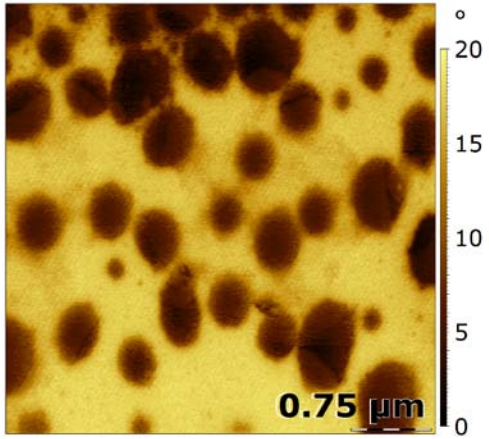
Trapping myoglobin by anionic polymer





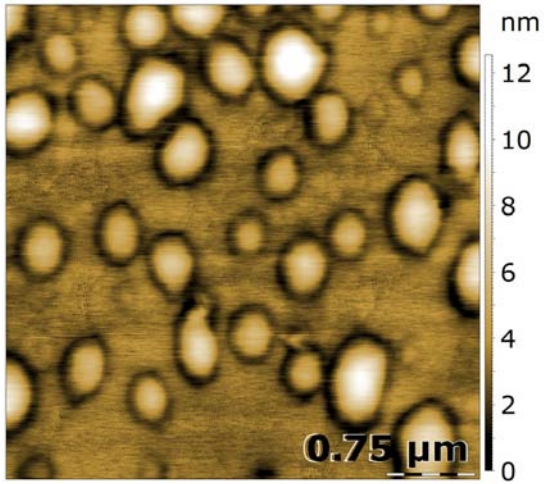


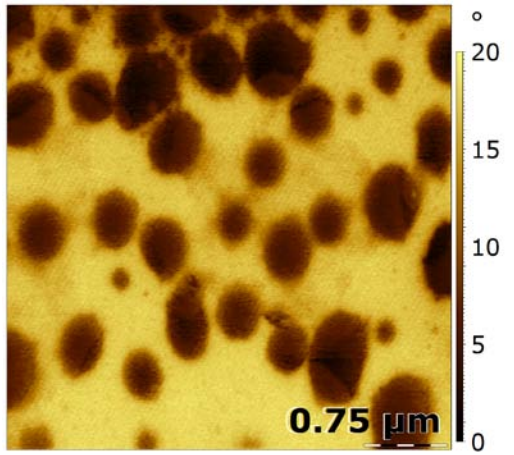




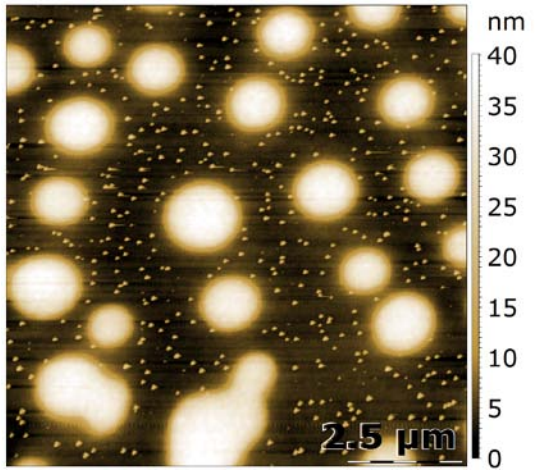
Results:

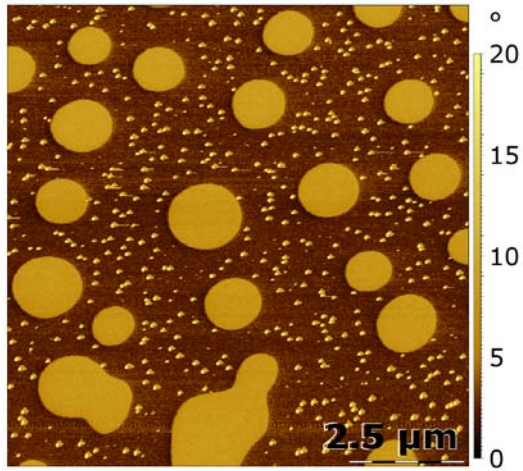
Protein fitted film sample
E(protein) /E(polymer)= 10





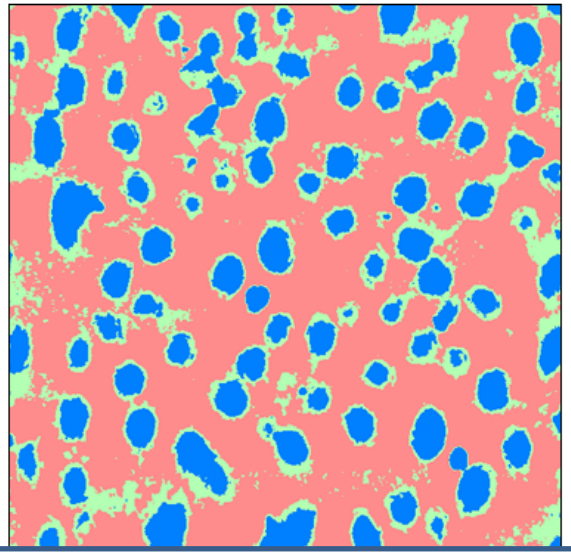
Reference
sample of two
different polymers:
E(brown) /E(yellow)= 10

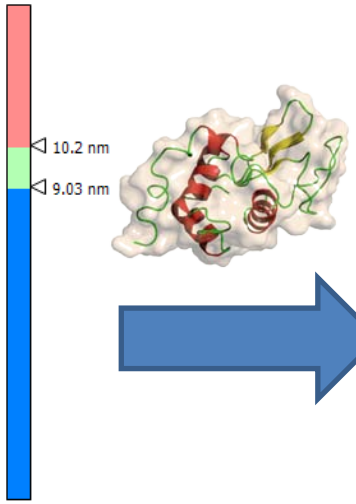


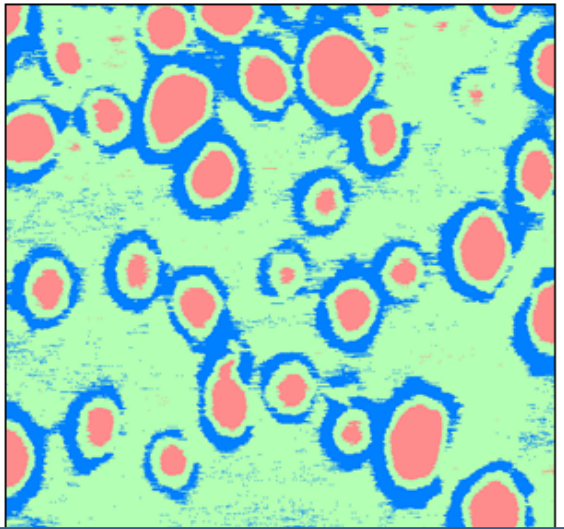


Results:

Trapping myoglobin by anionic polymer



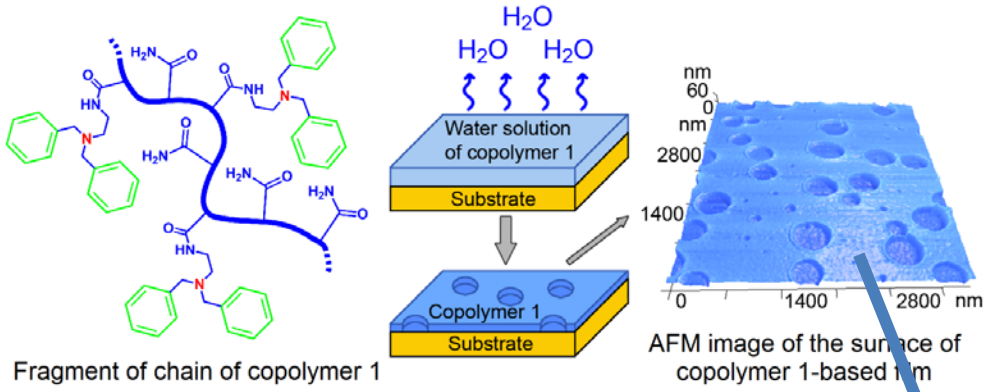




Mean depth of cavities 8,7 nm
Cavities represent 20% of surface

Mean height of proteins 7,8 nm
Filled cavities reprent 12,5% of surface

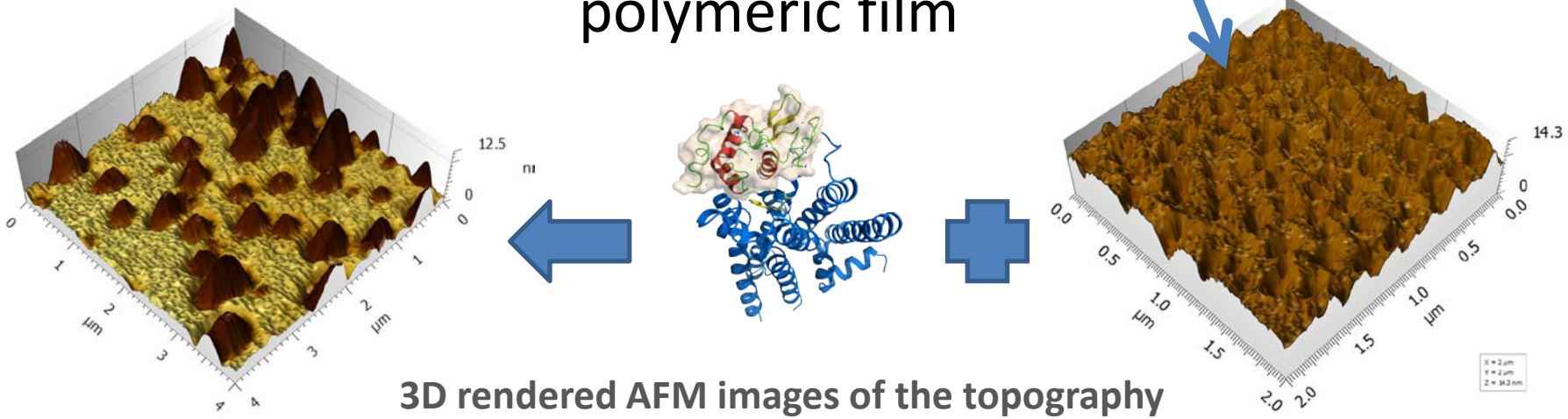
Bio MACROMOLECULES sensing



Fragment of chain of copolymer 1

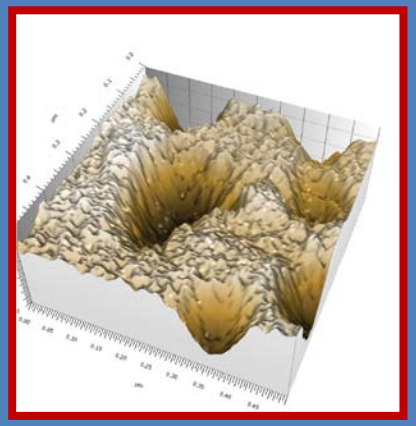
AFM image of the surface of copolymer 1-based film

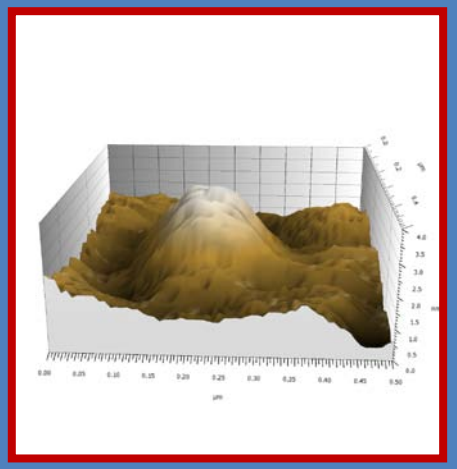
Myoglobine nanotrapping by nanostructured polymeric film



3D rendered AFM images of the topography information and bimodal colors.

We have developed nanoprocessing procedure for the preparation of nanostructured layers of bioactive polymers for trapping biomacromolecules at nano scale.





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€€€

Consolider Program, CIBER Actions and financed by the Instituto de Salud Carlos IIIwith assistance from the European Regional Development Fund.
Projects:
BE-WELL (CTQ2013–40480-R) granted by DGI (Spain),
GenCat (2014-SGR-17) and TecnioSpring program financed by DGR (Catalunya)
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