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Department of Biotechnology

Research Team name: **Laboratory for Colloids, Polyelectrolytes and Interfaces**
Presenter name: **Dr. Duško Čakara**

Team Presentation – Annual Workshop, COST Action MP1106
Dublin, September, 2012

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- Recently formed, currently moving into new premises (new University campus)
- Funding: EU/IPA (effective in 2013), Croatian Science Foundation (CSF)

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Center for Micro and Nano Sciences and Technologies:

- 5 tenured scientists, 6 PhD students
- Laboratories:
  - Laboratory for Colloids, Polyelectrolytes and Interfaces
  - Laboratory for Surface and Materials Physics (CSF project)
  - Laboratory for Macromolecular Research
  - Laboratory for Precision Engineering and Micro-systems Technologies (CSF project)
  - Laboratory for quantum and nonlinear optics
- Aim: interdisciplinarity btw. physics, chemistry and biology/medicine

Department of biotechnology:

- 20 tenured scientists, 4 PhD students
- CSF Project: High throughput analytical platforms for the food quality control and authenticity verification (mass spectroscopy, proteomics)

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Equipment at the CMNST (currently present):

- X-ray photoelectron spectrometer (XPS) – elemental analysis in thin films
- Metrolaser Vibromet 500V Laser Doppler Vibrometer
- Educational Scanning Tunneling Microscope (STM)
- Mobile and Fixed Lasertex Laser Interferometric Systems
- Basic chemical analytical tools, High performance ion-exchange cromatography

Equipment in the process of acquisition (functioning previewed in 2013):

- **High precision potentiometric titrator with ionic strength control**
- Static and dynamic light scattering instrument - zetasizer
- Simultaneous electrochemical impedance spectroscopy / surface plasmon resonance – simultaneous voltammetric (ion-to-electron charge transfer) and chemical structure measurements at electrodes

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Laboratory for Colloids, Polyelectrolytes and Interfaces (LCPI):

• Laboratory head: Ass. prof. Duško Čakara, PhD in chemistry (2004, University of Geneva)

• Expertize: Experimental studies and modelling of ion binding by polyelectrolytes and colloids in aqueous medium, colloidal interactions.

• LCPI is currently applying for projects, teaming up and equipping

High precision potentiometric titratior with ionic strength control

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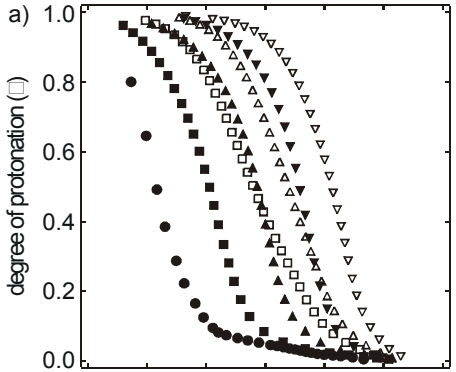
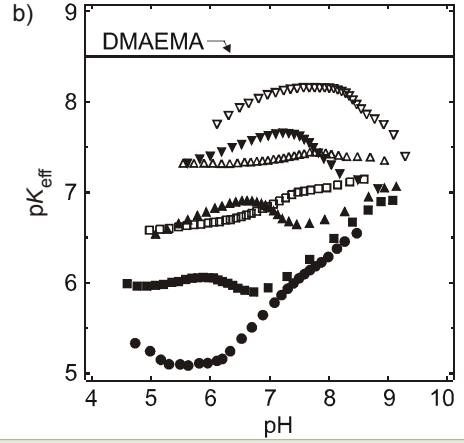
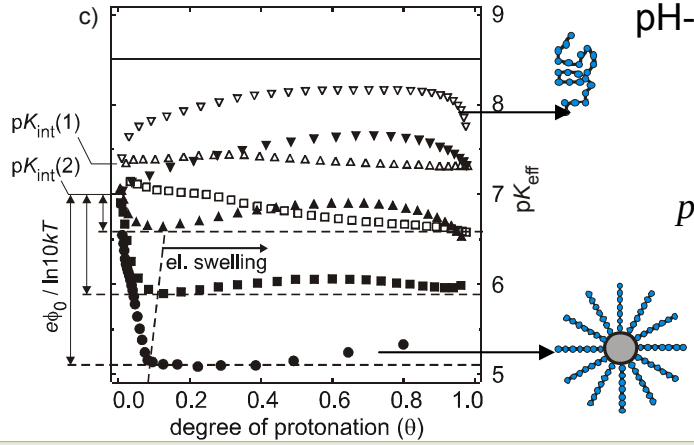
High precision potentiometric titrations:

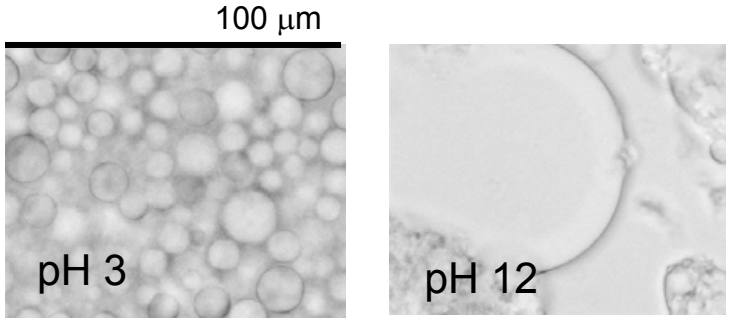
A powerfull tool for studying acid-base equilibria of dissolved and adsorbed polyprotic molecules and of the colloidal particle surfaces (ion adsorption equilibrium)

Example 1: charging of the block-copolymer 'frozen' micelles ('annealed' spherical brushes - SPB)









pH-switchable Pickering emulsions

$$pK_{eff} = \log(\frac{\theta}{1-\theta}) + \mathrm{pH} = pK_d - \frac{e\phi_0(\theta, I)}{2,303kT} + \ldots$$

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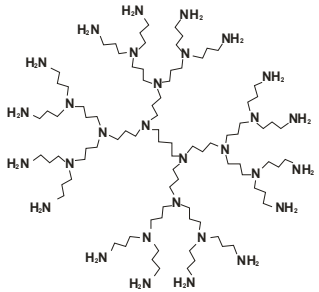
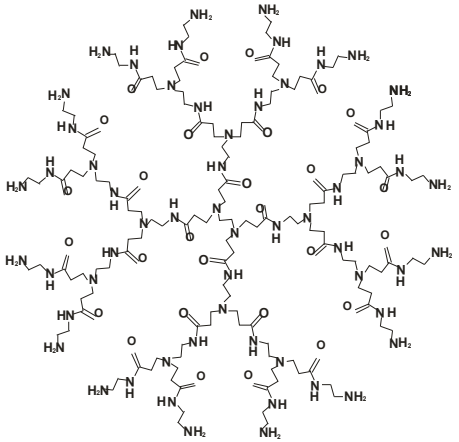
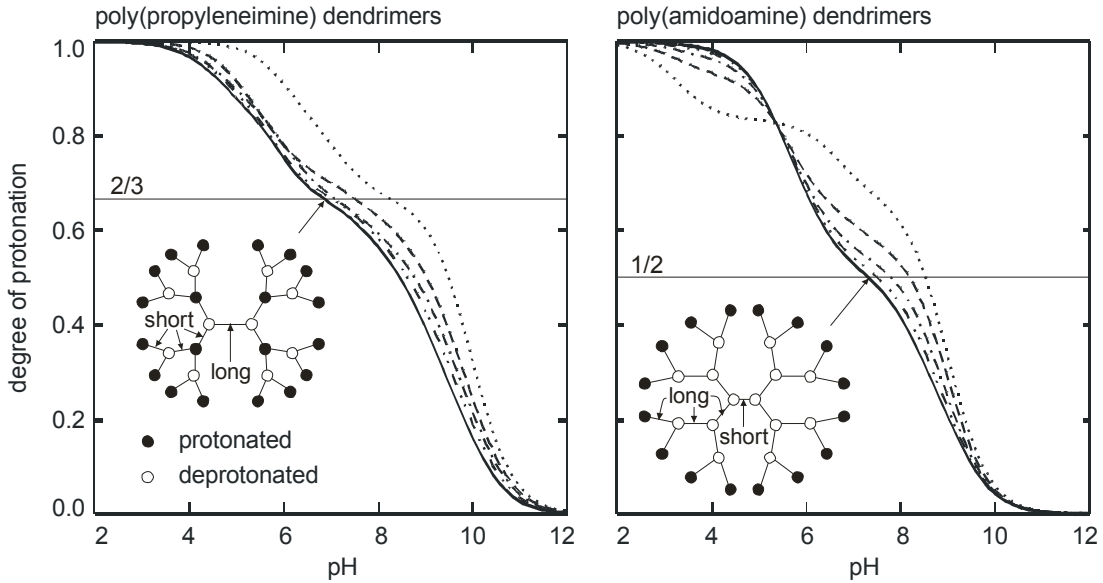
High precision potentiometric titrations

Example 2: protonation mechanisms







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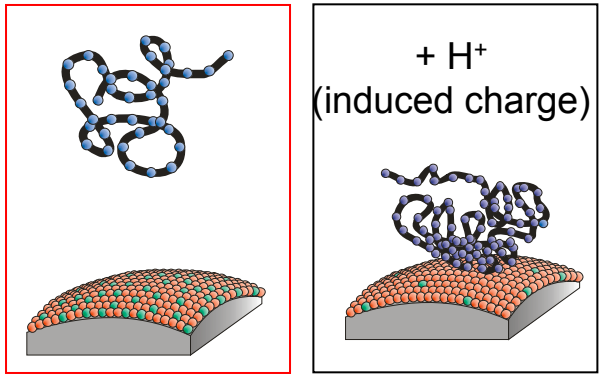
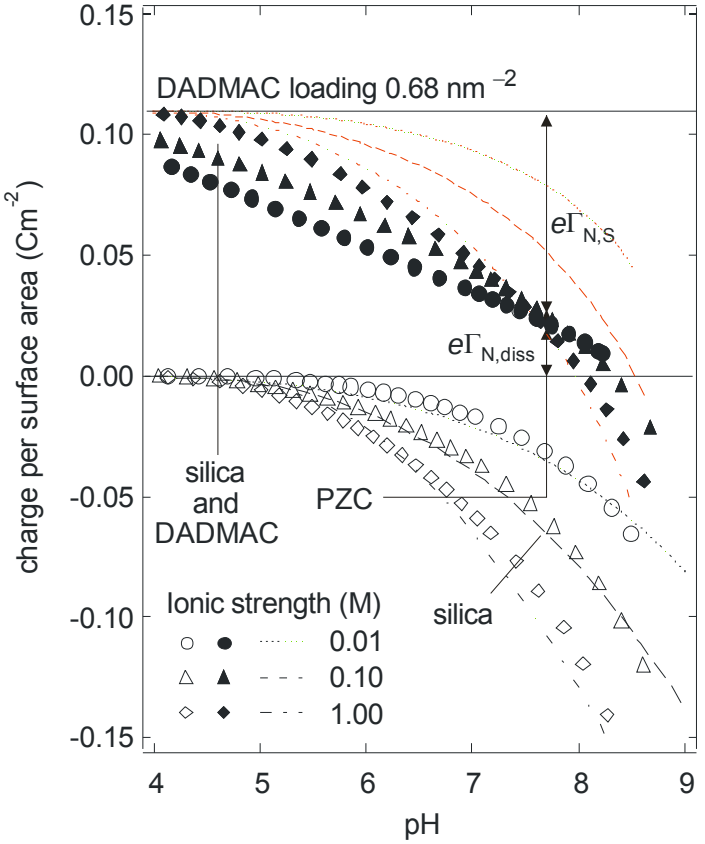
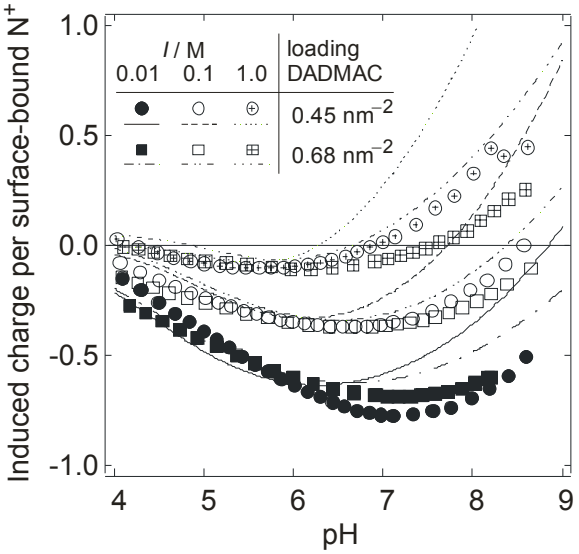
High precision potentiometric titrations

Example 3: measurements of charge ratios and induced charge upon weak polyelectrolyte adsorption as function of pH







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Laboratory for surface and materials physics (Prof. Mladen Petravić, head):

- Modification of composite semiconductor surfaces by means of ion beam.
- Characterization of semiconductor surfaces by means of photoelectron spectroscopy (elemental analysis with a low detection limit)
- Limits: ultra-high vacuum methods (!)

X-ray photoelectron spectrometer

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Research interests related to MP1106:

• Method development for measuring ion binding at air/water interface

• Fundamental aspects of ion, polyelectrolyte and nanoparticle adsorption at air/water interface - charging equilibria vs. shape and stability of the interfaces

• Charge-structure-functionality relationships in polyelectrolytes (or possibly proteins) physically or chemically bound at interfaces

• Biocompatible and biodegradable foam and droplet stabilizers (e.g. carbohydrates)

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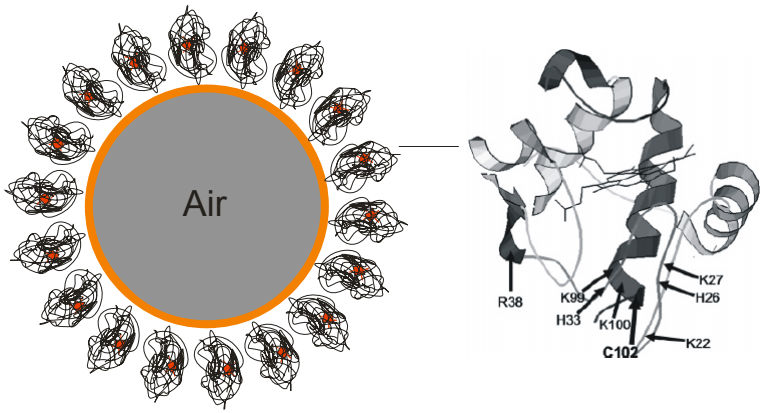
Project proposal:
Title: Proteins at Air/water Interface: From Fundamentals to Applications
Aim: Study the function of proteins at air/water interface, as function of solution properties (pH, ionic strength, temperature…)
Challenge: avoid protein denaturation; solid particles -> gas bubbles
Smart: Gas bubbles are compressible (adds one degree of freedom)
Green: Proteins are by definition green.
Technological relevance: biocatalysis, applications in bomedicine, clean energy...

Expertise required: Proteins at interfaces (preparation and structure characterization), stabilization of bubbles by small molecules, ion binding, thermodynamics, reaction kinetics, protein conformation modeling, biocatalytical process engineering, protein synthesis and biochemical tailoring, analytical tools for determining protein primary structure (MS)...

Facilities/equipment required: Radiation scattering tools (static/dynamic light scattering, x-ray scattering), surface tension measurements, *in situ* electrochemical methods (potentiometry, cyclic voltammetry), basic spectroscopic methods, mass spectroscopy for protein analysis…



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Thank you for your attention