International Summer School for young scientists
NANOTECHNOLOGY: from fundamental research to innovations
August 26 - September 2, 2012, Bukovel, Ukraine

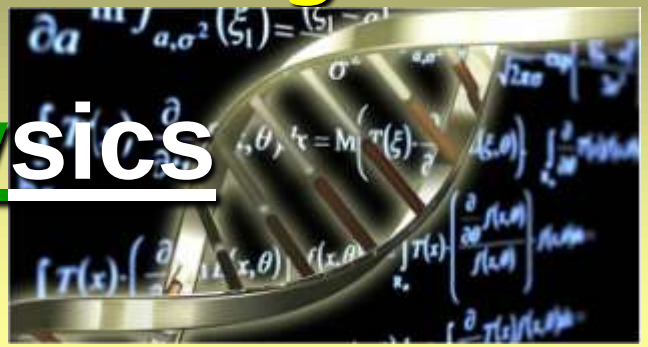
Study of nanocomposites of amino acids and organic polyethers by means of mass spectrometry and molecular dynamics simulation

V.G. Zobnina, V.V. Chagovets, O.A. Boryak, M.V. Kosevich, S.G. Stepanian

B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Science of Ukraine, Kharkov, Ukraine

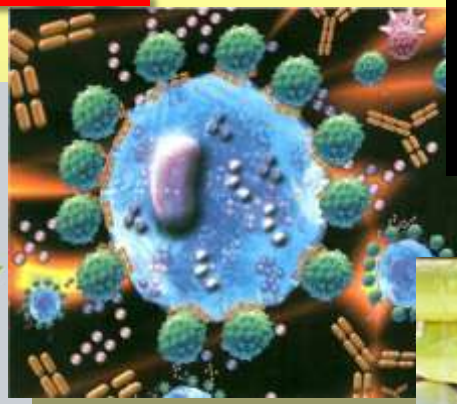
Nanoparticles of various materials are promising...

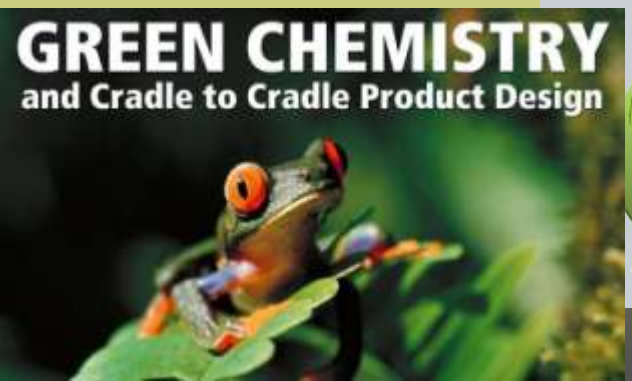
biophysics



cryobiology

nanobiotechnology



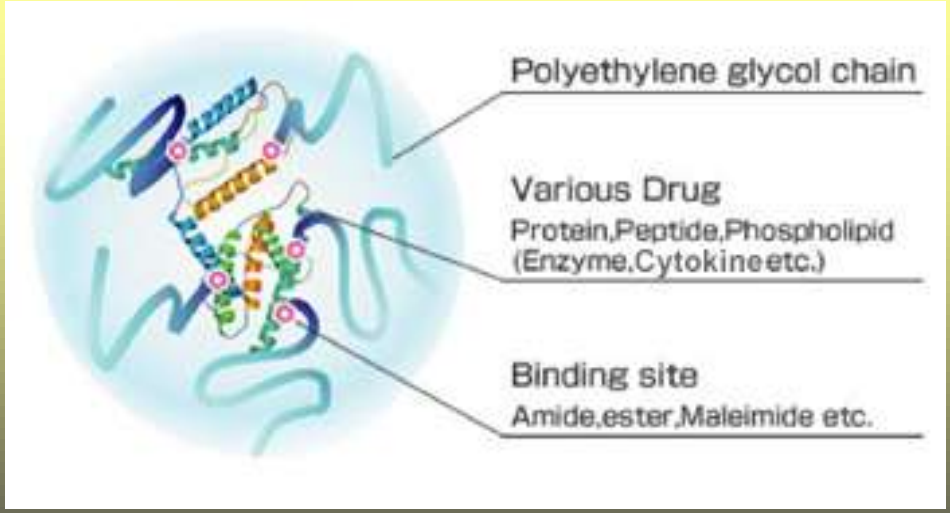


pharmacology

OBJECTS: NANOPARTICLES composed of biomolecules and organic polymers

Applications

- **Pegylated proteins**
- **Nanocomposites based on organic polymers**
- **for drug delivery**



AIM:

To understand the structure and self-assembling of nanoparticles determined by interactions of polyether chains with protein amino acids

TASK:

To study nanocluster interaction on simple model of nanoparticles consisting of polyether oligomers and amino acids by means of a combined approach of experiment - electrospray mass spectrometry and computer modeling - molecular dynamics calculations.

Object:

NANOPARTICLES =

organic polymers
polyethers

Polyethylene glycol
and its derivatives

+

Amino acid

PEG-400

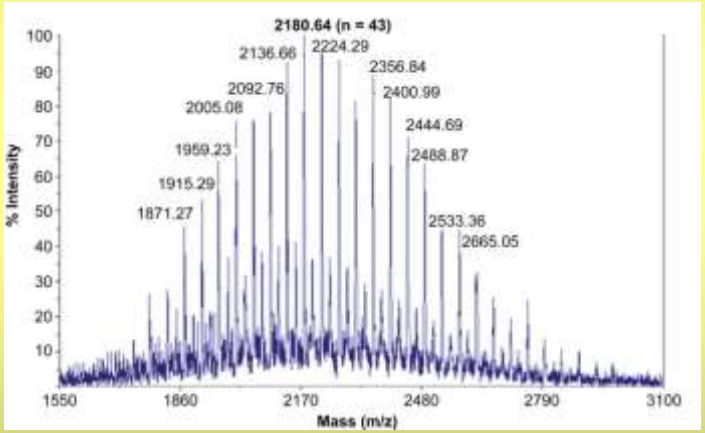
Polymers have no an individual mass number, it is not a single molecule, but a set of olygomers

This property is called polydispersity

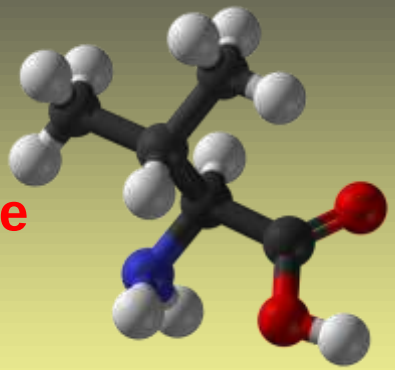
The name of polymer is given for its average mass (n =polymeryzation degree)

IUPAC
International Union of Pure and Applied Chemistry

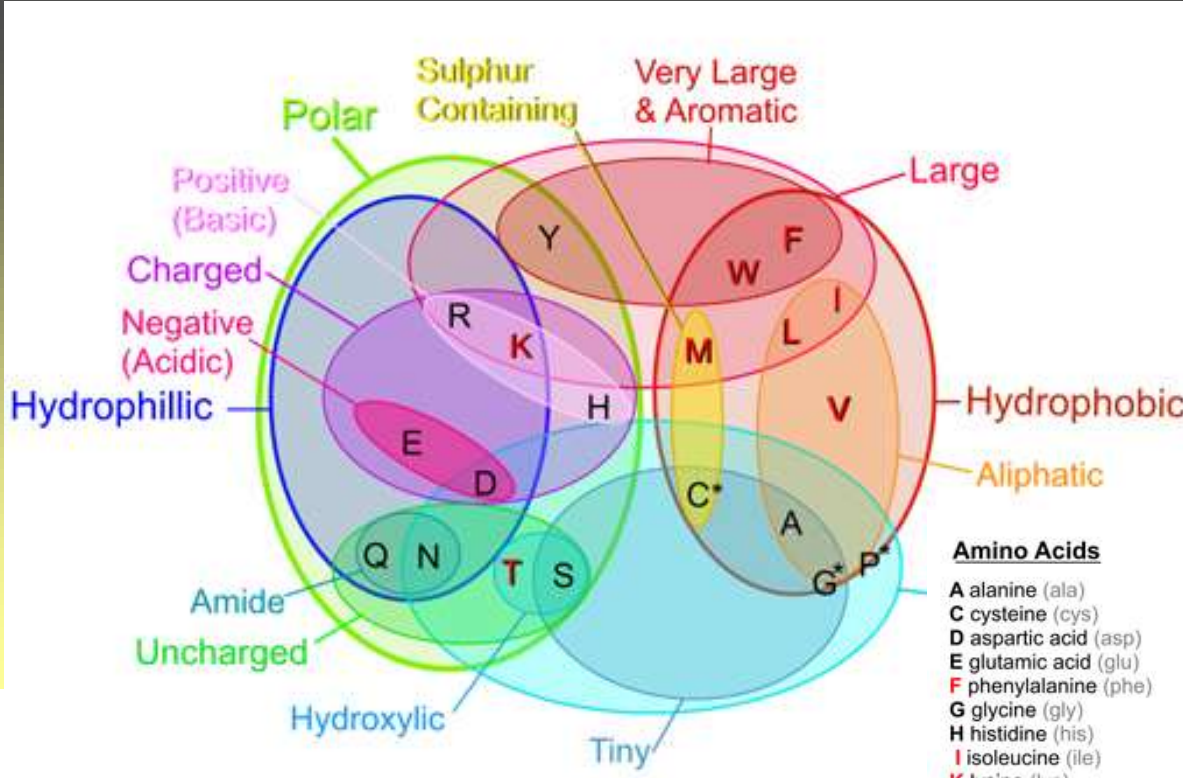
Dispersity ($Đ$) is defined as $Đ = M_m/M_n$ where M_m is the mass-average molar mass and M_n is the number-average molar mass.



Amino acids



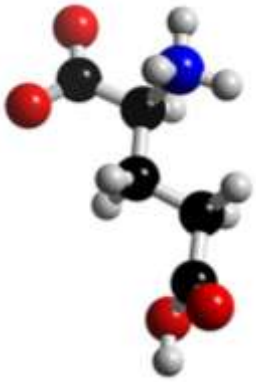
Valine



Amino Acids

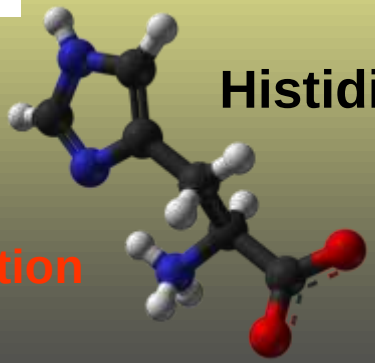
A alanine (ala)
C cysteine (cys)
D aspartic acid (asp)
E glutamic acid (glu)
F phenylalanine (phe)
G glycine (gly)
H histidine (his)
I isoleucine (ile)
K lysine (lys)
L leucine (leu)
M methionine (met)
N asparagine (asn)
P proline (pro)
Q glutamine (gln)
R arginine (arg)
S serine (ser)
T threonine (thr)
V valine (val)
W tryptophan (trp)
Y tyrosine (tyr)

Glutamic acid



Anion

Aspartic acid

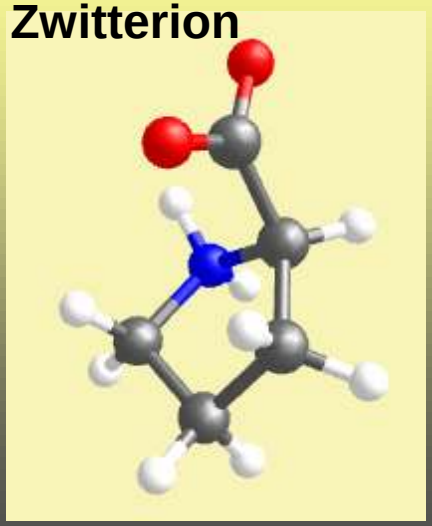


Cation

Histidine

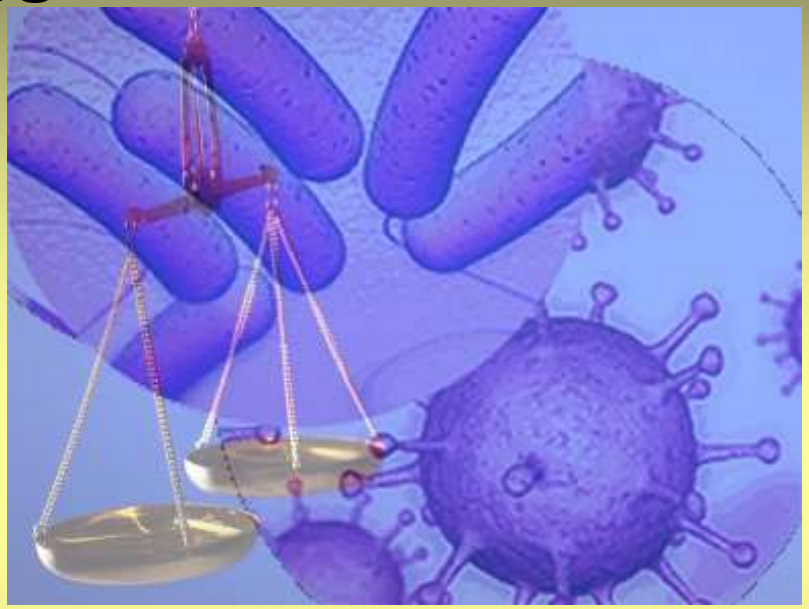
Proline

Zwitterion

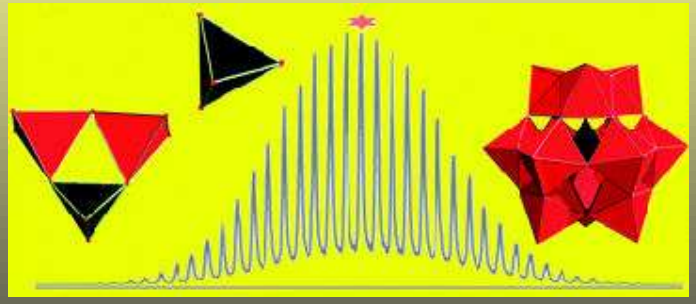


Mass spectrometry

is an efficient tool in studies of noncovalent complexes of organic and biological molecules

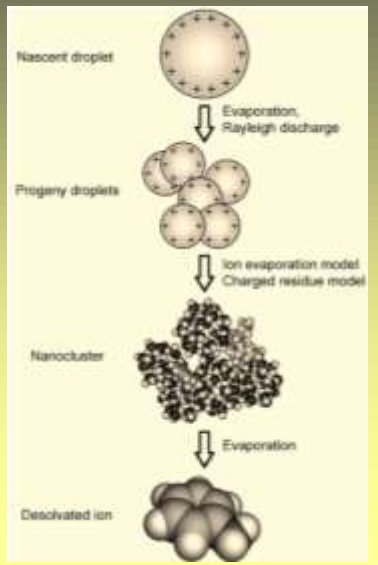


monitoring of self-assembling of nanoparticles



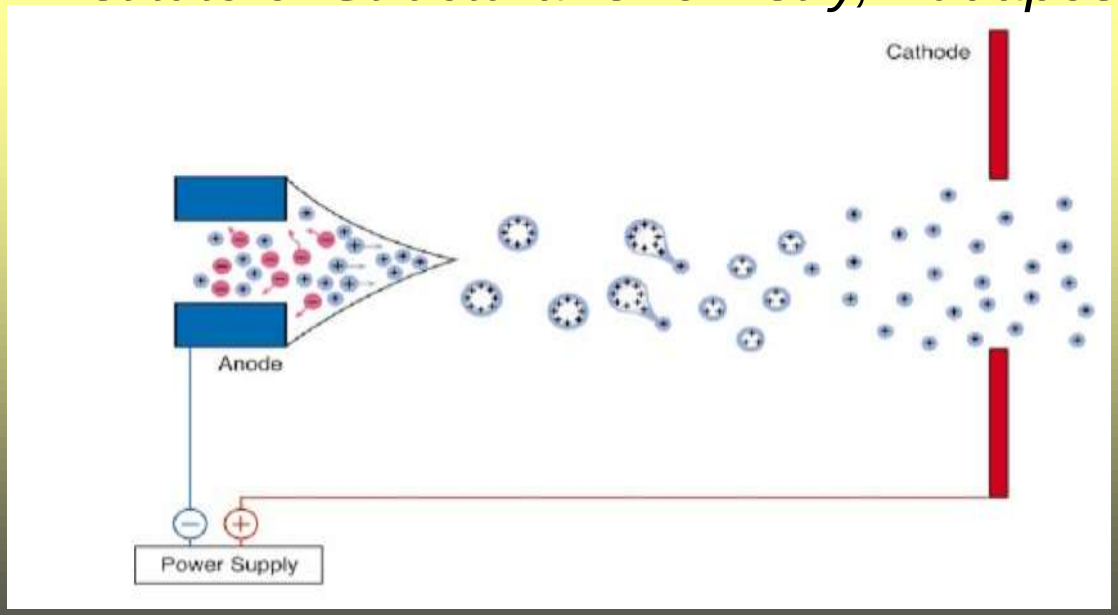
METHODS:

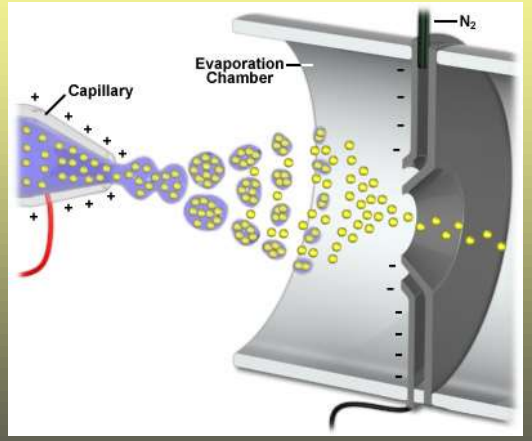
Mass spectrometry



Mass spectrometry with electrospray ionization (ESI)

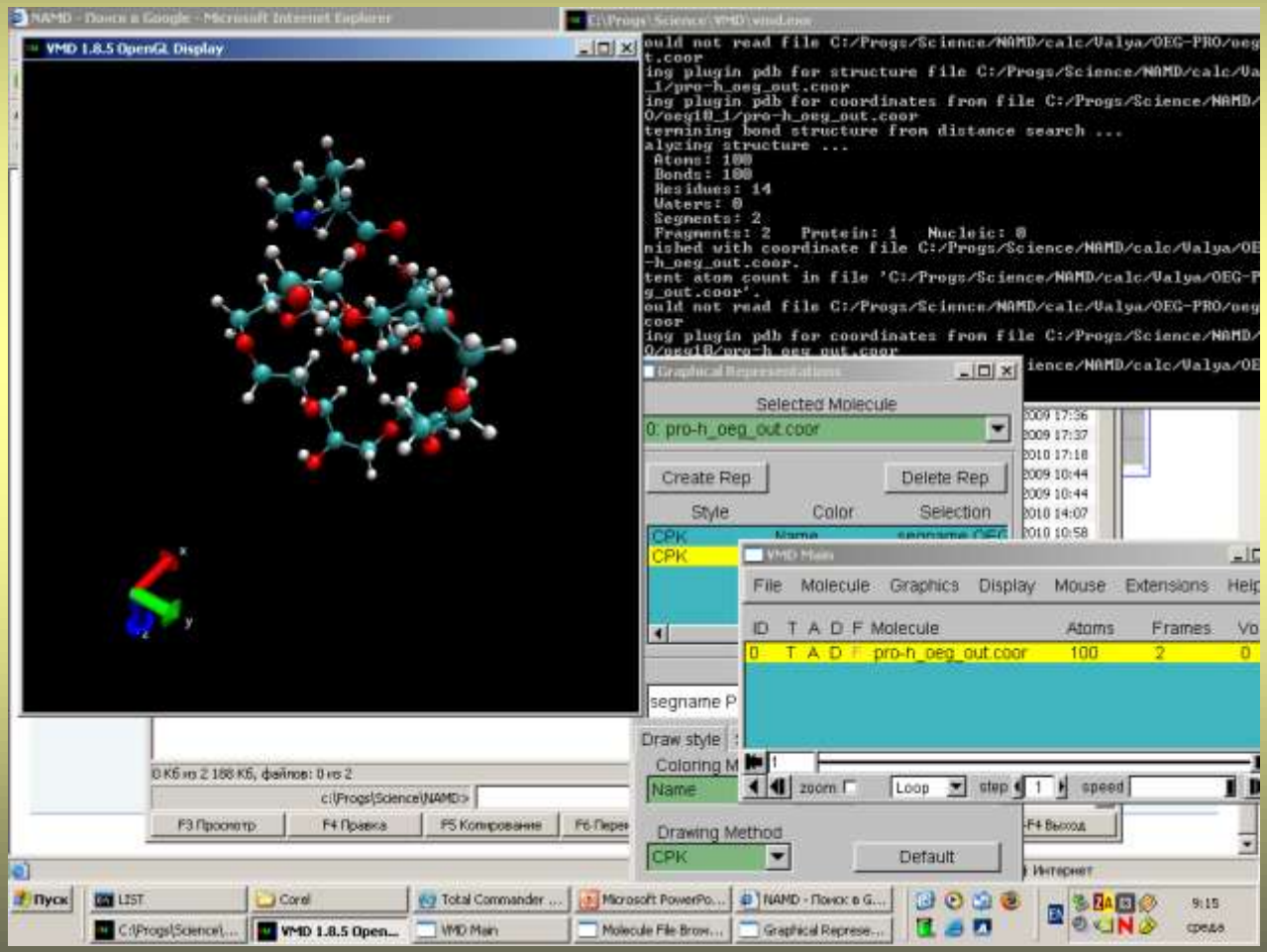
PE Sciex API 2000 Triple Quadrupole MS (PE Sciex, Canada) *in collaboration with Institute of Structural Chemistry, Budapest*



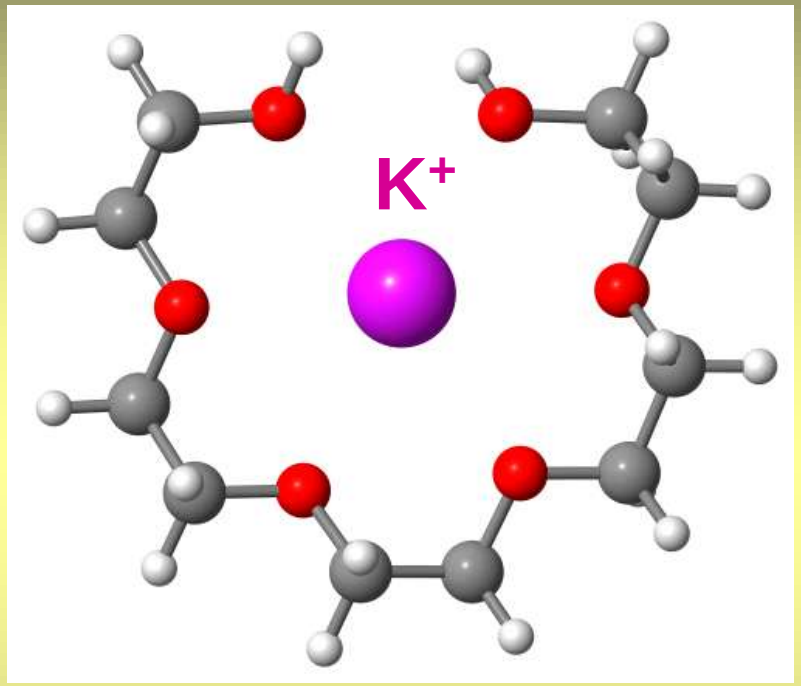


Molecular dynamics simulation

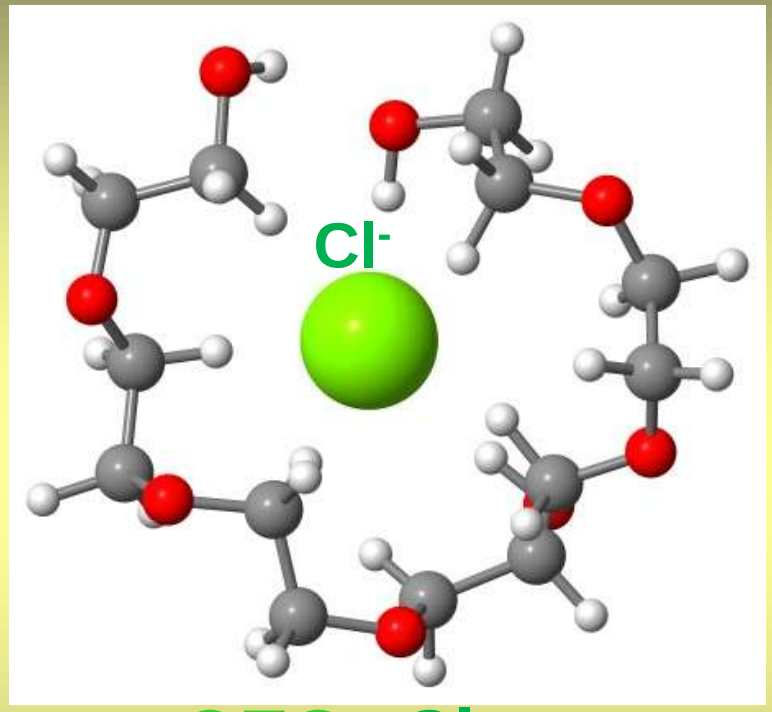
To establish structures of complexes registered in mass spectrometric experiment



POLYMERIC CHANE WRAPS AROUND THE IONS IN Polymer •inorganic ion COMPLEXES



$PEG_5 \bullet K^+$



$OEG_5 \bullet Cl^-$

Assumption: similar structures can be formed with organic ions

Observation of poly (ethylene glycol) clusters with the chlorine anion in the gas phase under electrospay conditions // Rapid Communications in Mass Spectrometry, 2011, V.25, N. ,P. 713-718

Experimental results

Valine and proline – representatives of hydrophobic amino acids

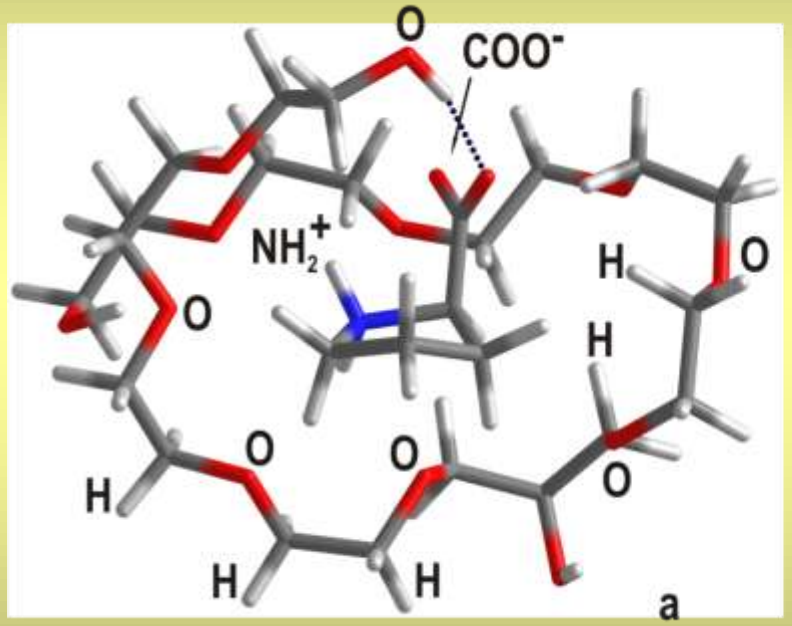
Experimental results

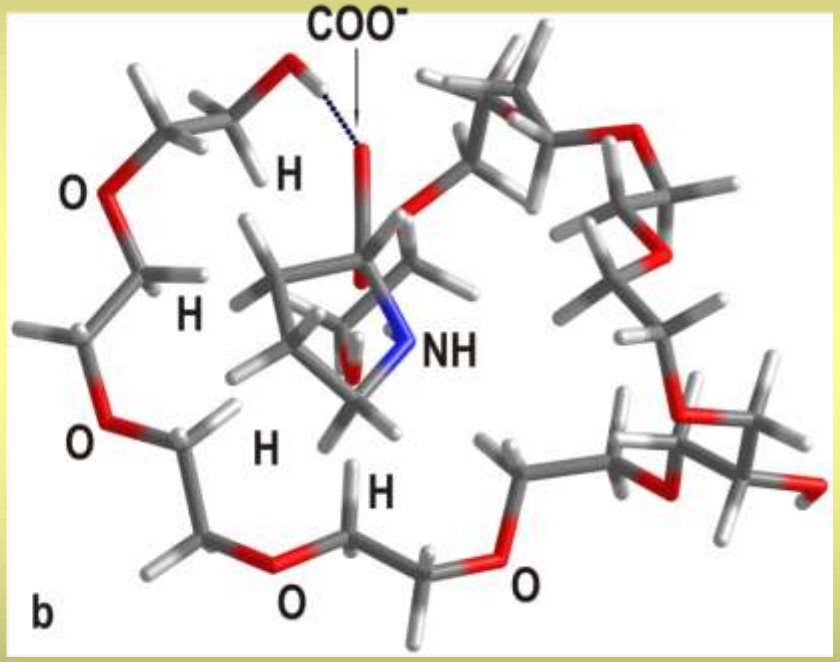
ESI mass spectra of “Valine – OEG” nanoclusters

Косевич М.В., Зобнина В.Г., Боряк О.А., Шелковский В.С., Гомори А., Векей К. Исследование раствора аминокислоты валина в криопротекторе этиленгликоле при низких температурах методом вторично-ионной масс-спектрометрии // Масс-спектрометрия, 2006, Т. 3, N 1, С. 33-42.

Computer Simulation

Structures of complexes formed by oxyethylated glycerol oligomers OEGn and PEGn with amino acid Proline





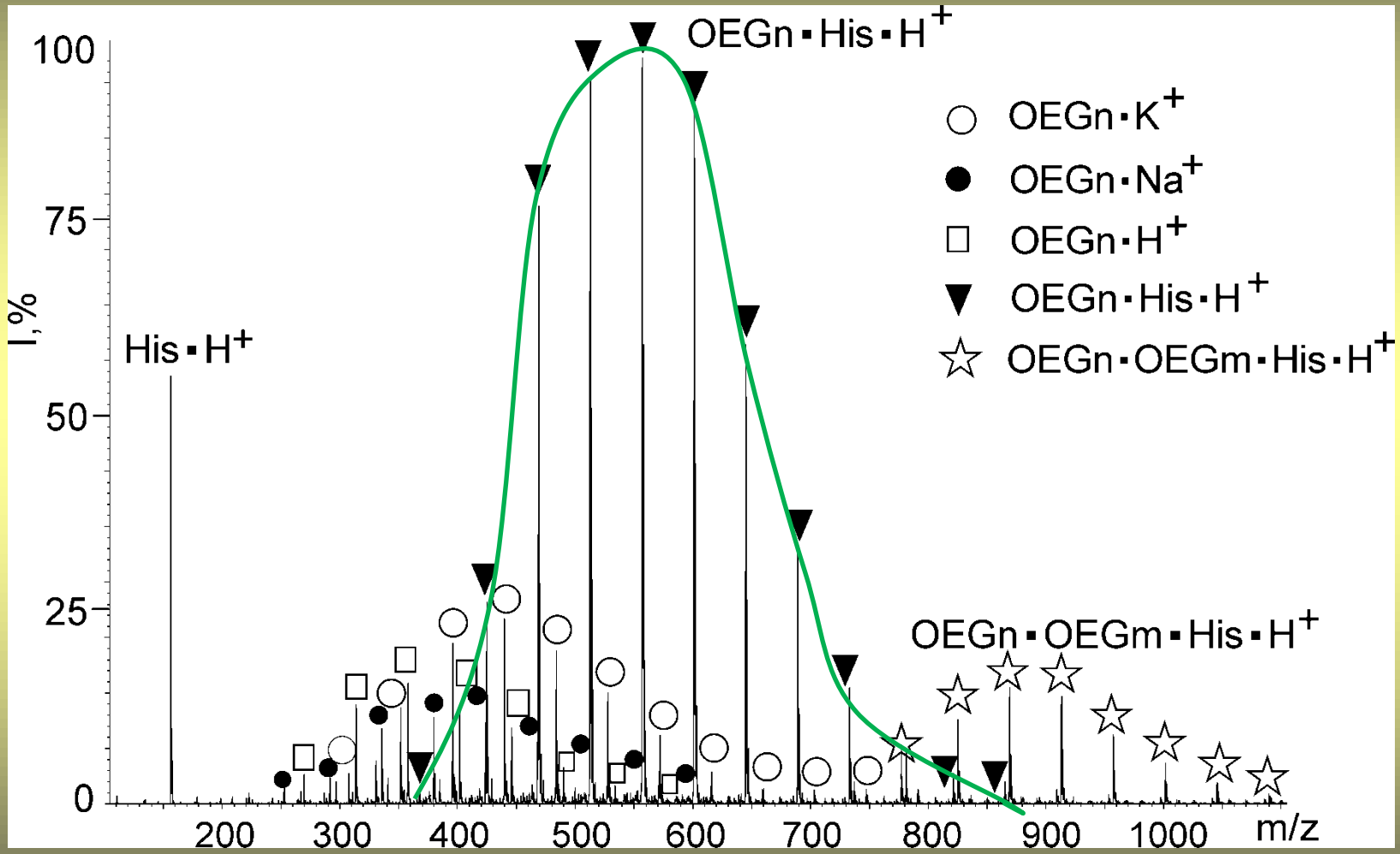
Protonated Proline

Deprotonated Proline

Histidine – representative of ionic positively charged amino acids

Experimental results

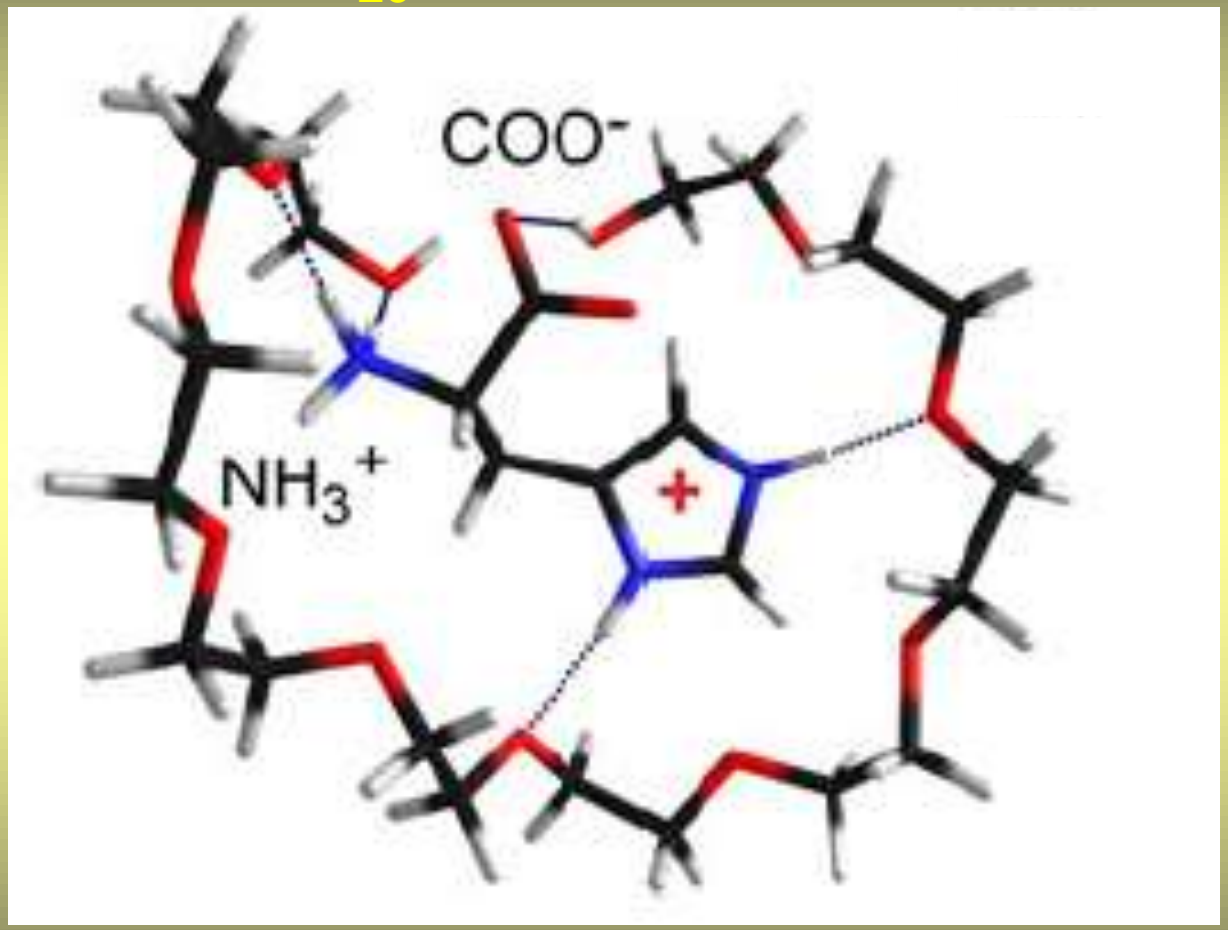
ESI mass spectra of “Histidine – OEG” nanoparticles



Interactions of oligomers of organic polyethers with histidine amino acid // Rapid Communications in Mass Spectrometry, 2012, V. 26, N 5. P. 532-540

Molecular dynamics simulation

PEG_{10}•His •H^+



His in cationic zwitterionic form

Aspartic acid,
Glutamic acid – representatives of ionic negatively charged amino acids

CONCLUSION

Structural assembling and organization in nanoparticles are realized owing to the wrapping of polyether chain around amino acids charged groups

The results obtained for the self-organization and structure of the studied model nanoparticles can be applied for modeling of the structure of the larger assemblies of proteins with polyethers using the same structural motifs