PREPARATION AND CHARACTERIZATION OF FUNCTIONAL METALLIC NANOPARTICLES AS POTENTIAL DRUG DELIVERY SYSTEMS

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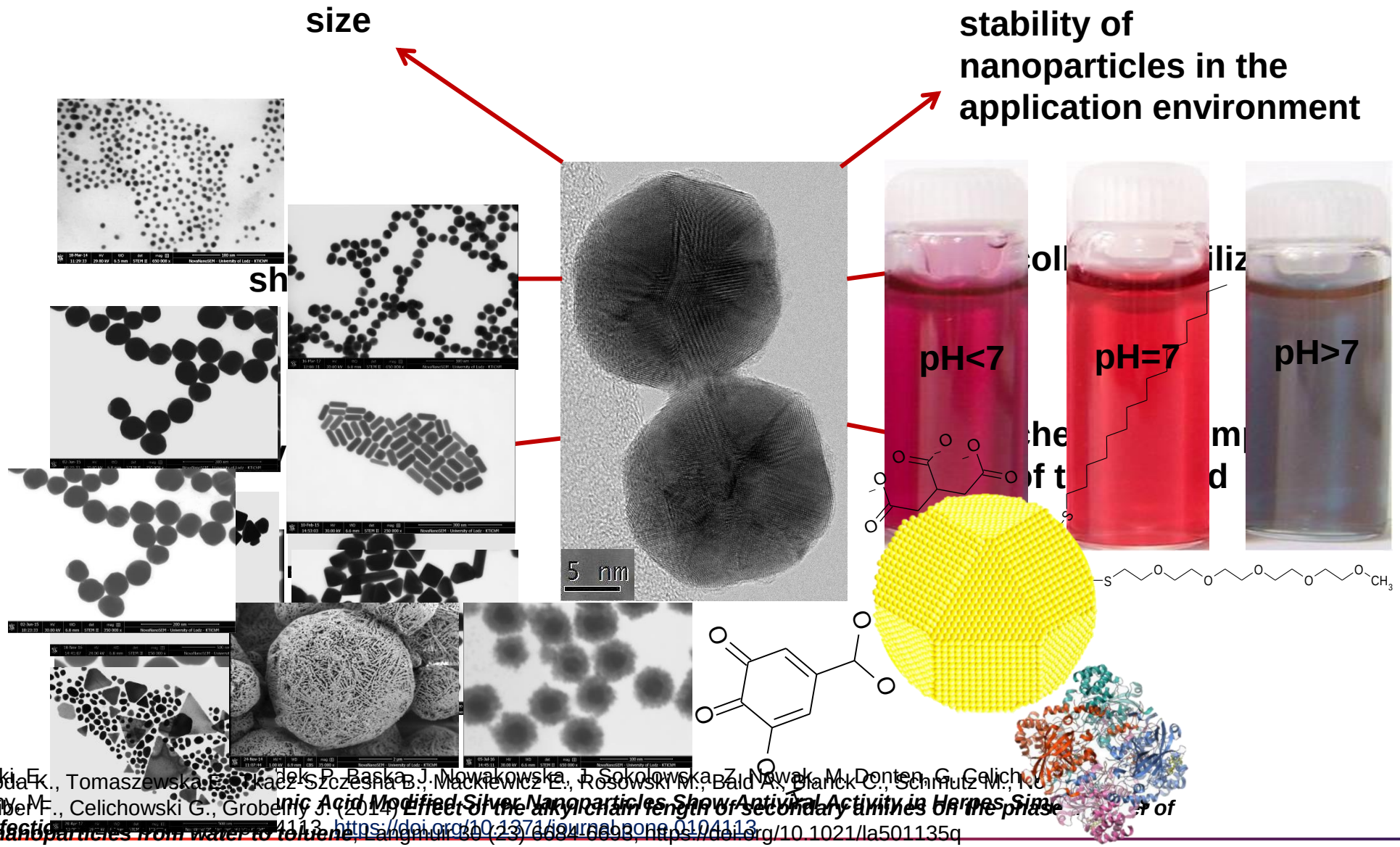
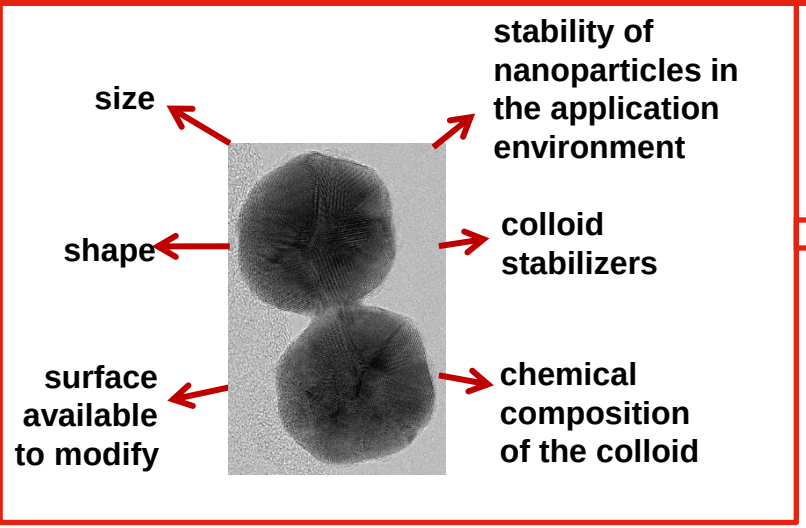
What determines the biological activity of nanoparticles?



P. Orlowski, E. Kmiec, J. Tomkowicz, J. Grobelny, M. Schreiber, F. Celichowski G., Grobelny J. (2014) *Type 2 Infectio* 4113. https://doi.org/10.1371/journal.pone.0104113

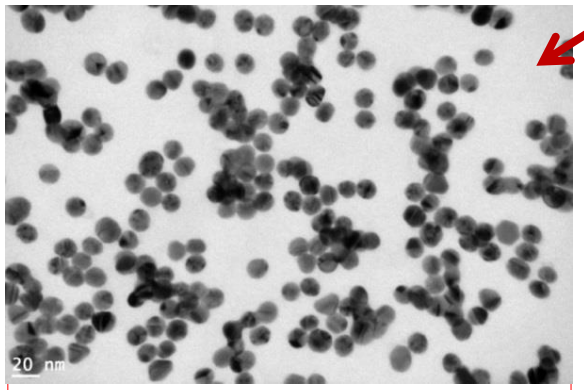
Sołtwoda K., Tomaszewska E., Kaez-Szczesna B., Mackiewicz E., Rosowski M., Bald A., Blarick C., Schmutz M., Ku *nic Acid Modified Silver Nanoparticles Show Antiviral Activity in Herpes Sim* *of gold nanoparticles from water to toluene*, Langmuir 30 (23) 6684–6693, https://doi.org/10.1021/la501135q

Synthesis of metallic nanoparticles by chemical reduction method

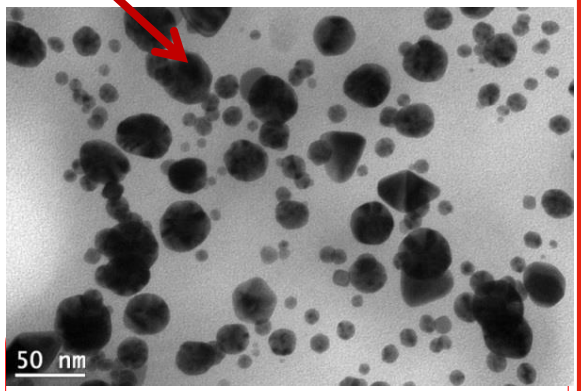


appropriately selected solutions of metal ions/anions/medium

reduction process with selected reducers in the presence of stabilizers



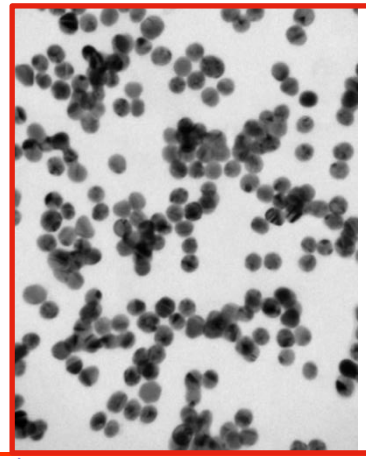
We want to introduce nanoparticles to the complex system of the human body!



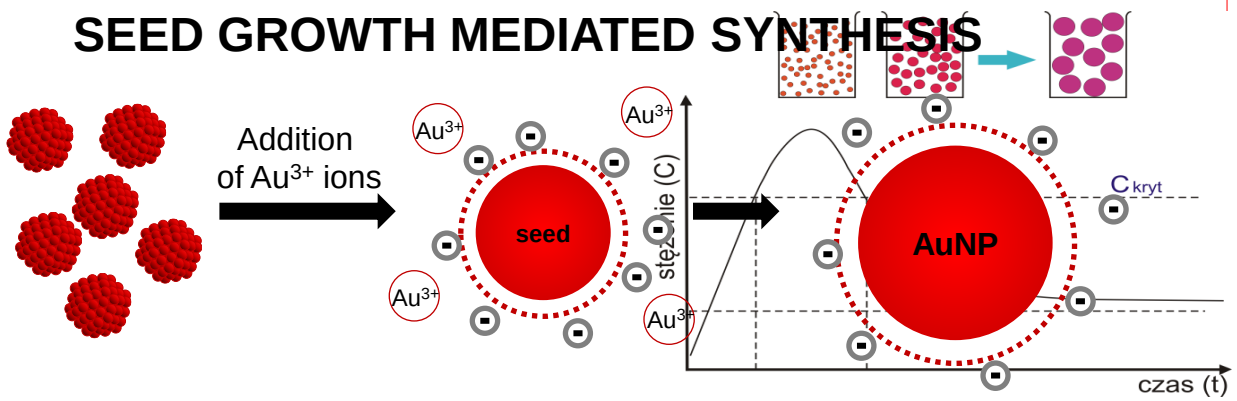
How to obtain larger nanoparticles without changing the composition of the colloid?

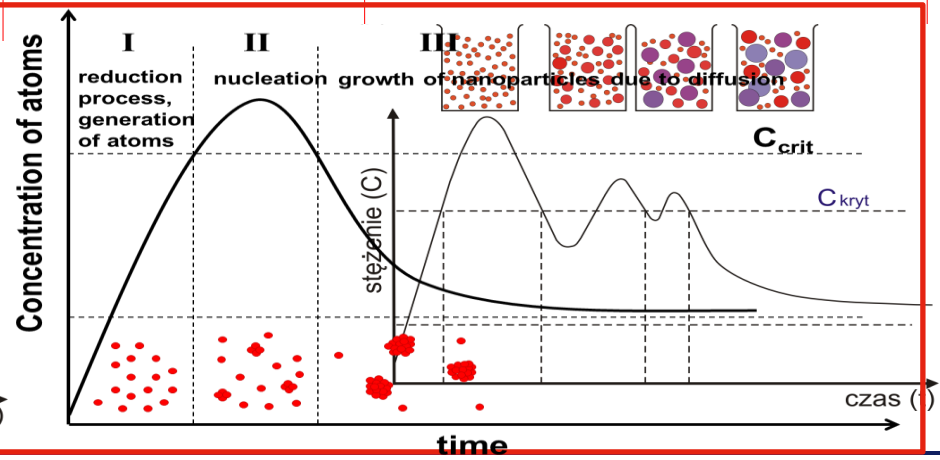
selection and precise control of all synthesis parameters

WITHOUT CONTROL



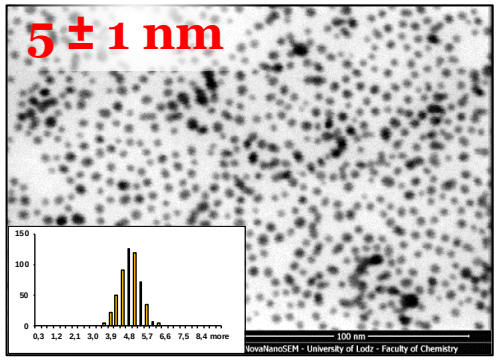
SEED GROWTH MEDIATED SYNTHESIS

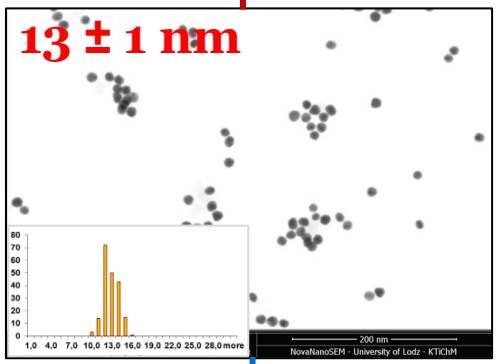


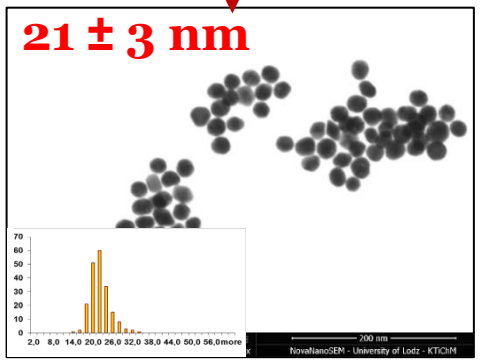


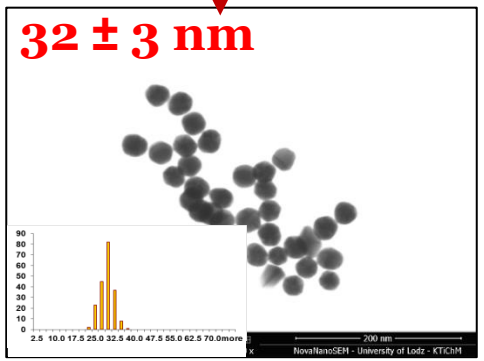
Obtained colloids of metallic nanoparticles

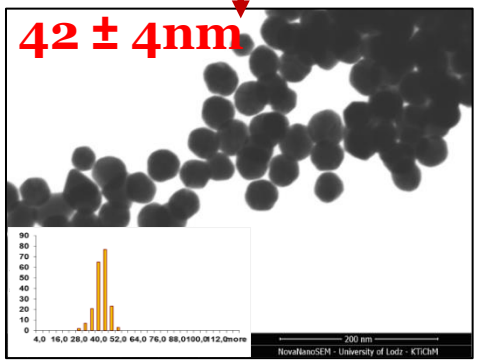
GOLD NANOPARTICLES









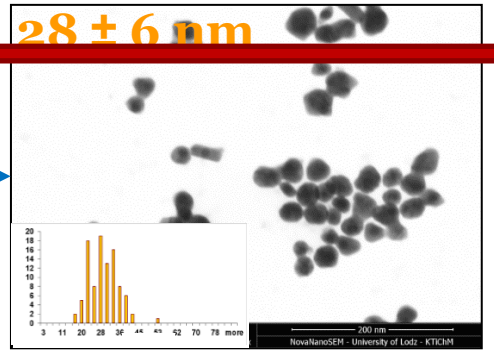


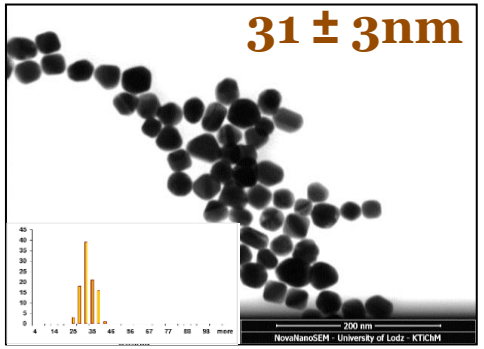
SILVER
on GOLD NANOPARTICLES

d ≈ 13 nm

d ≈ 20 nm

DIFFERENT SIZES

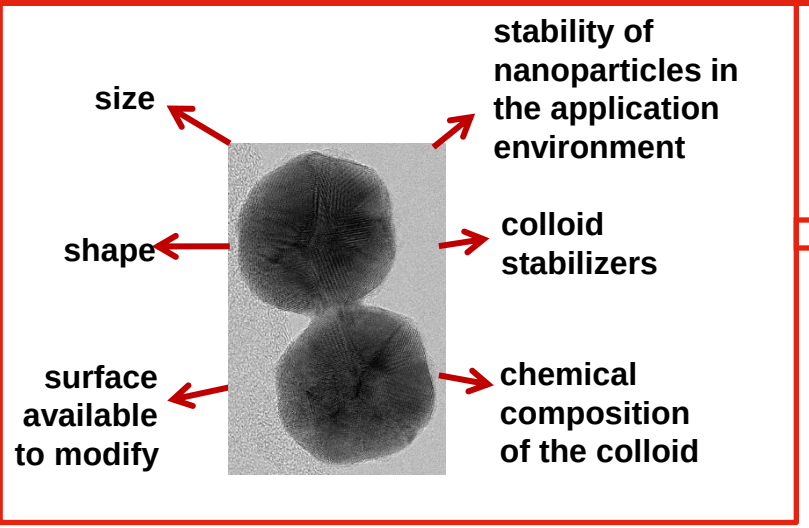


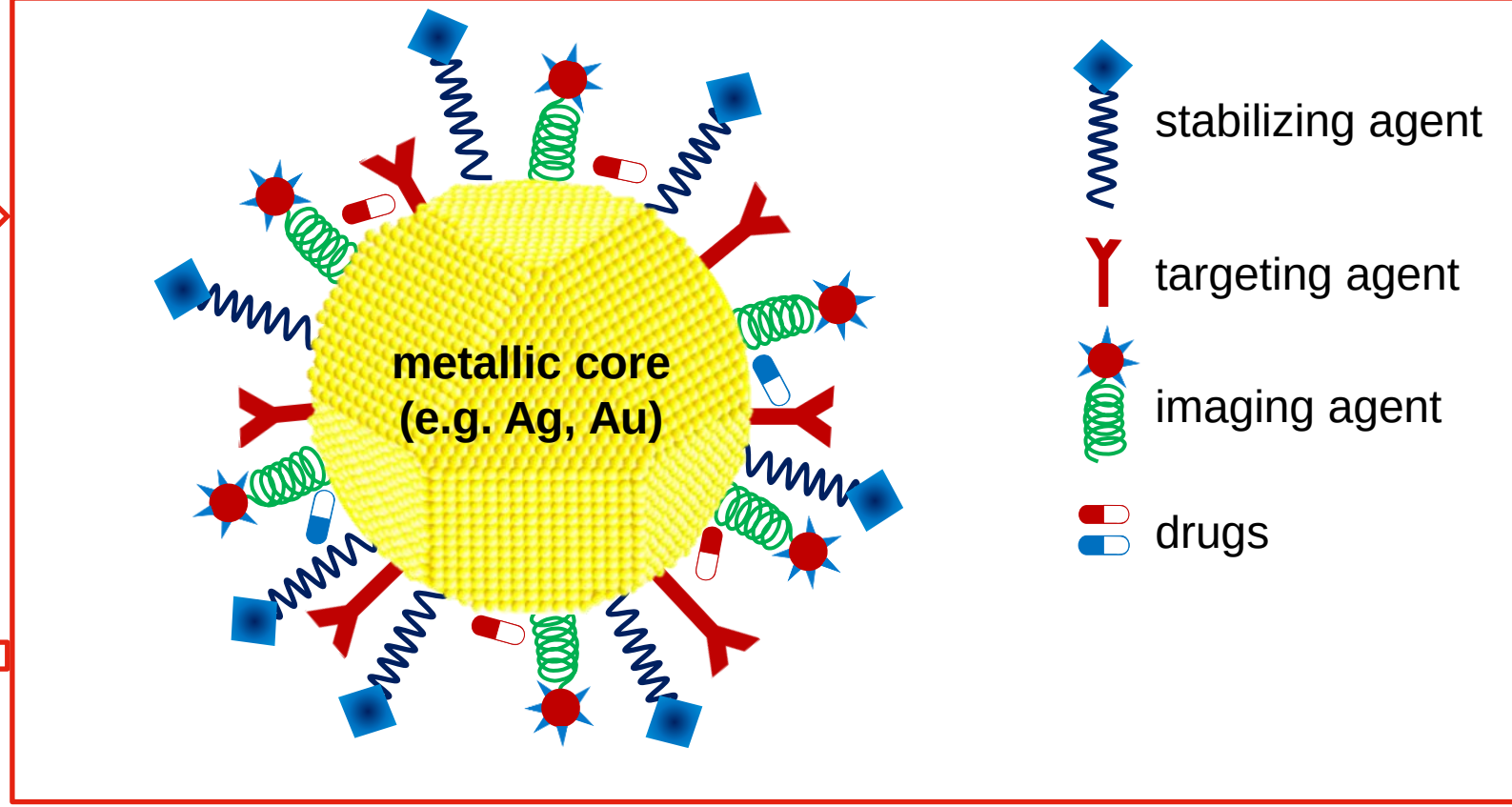


DIFFERENT METALLIC CORES

SILVER NANOPARTICLES

Multifuncional nanoparticles





WHAT WE NEED TO KNOW TO PLAN THE CREATION OF MULTIFUNCTIONAL NANOPARTICLES?

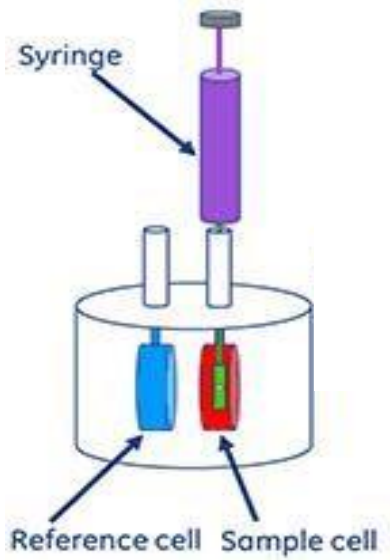
How many particles of different types of modifier have been absorbed on the metal surface?

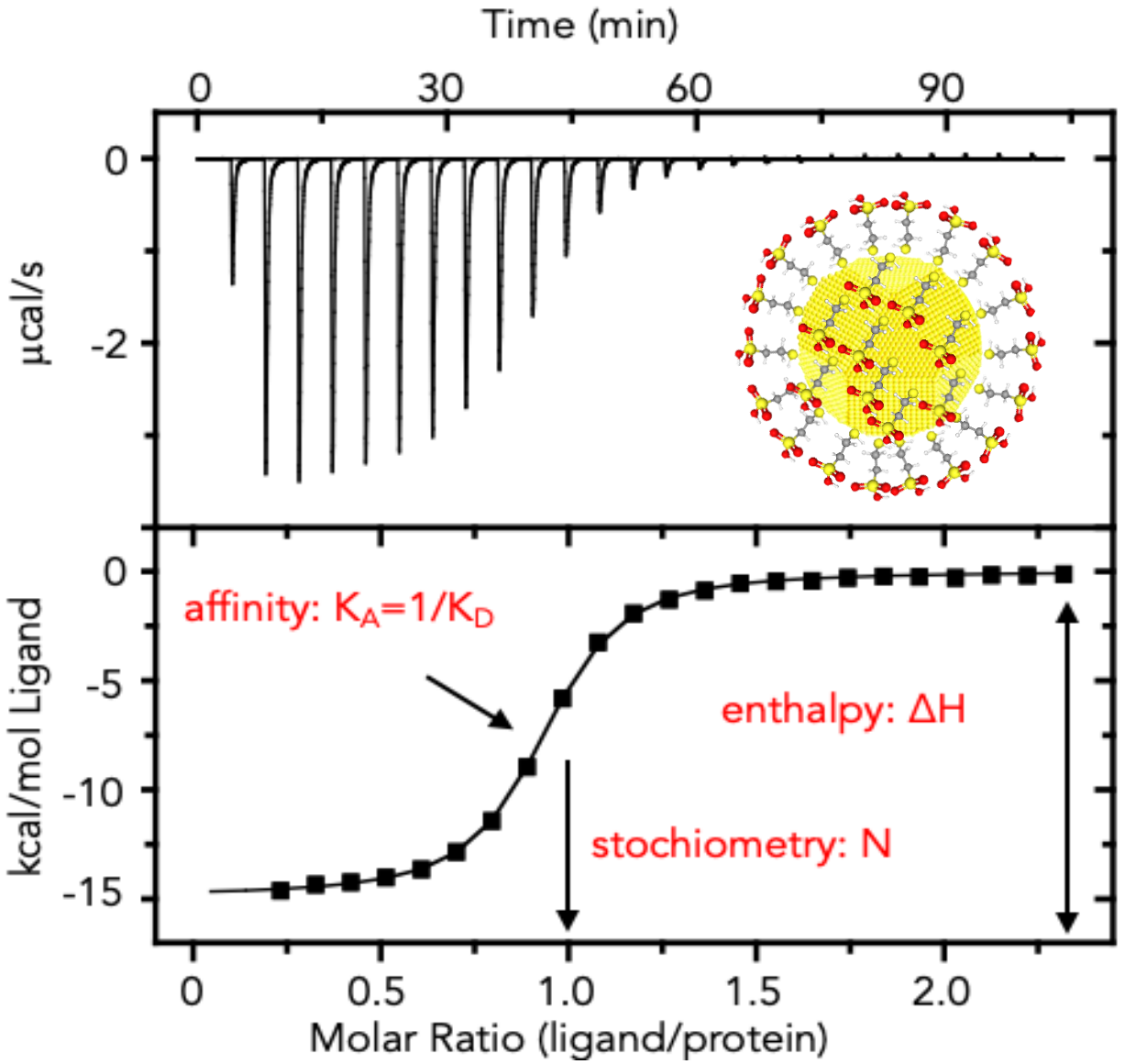
or

How many modifier molecules are needed to obtain full coverage of the nanoparticle surface?

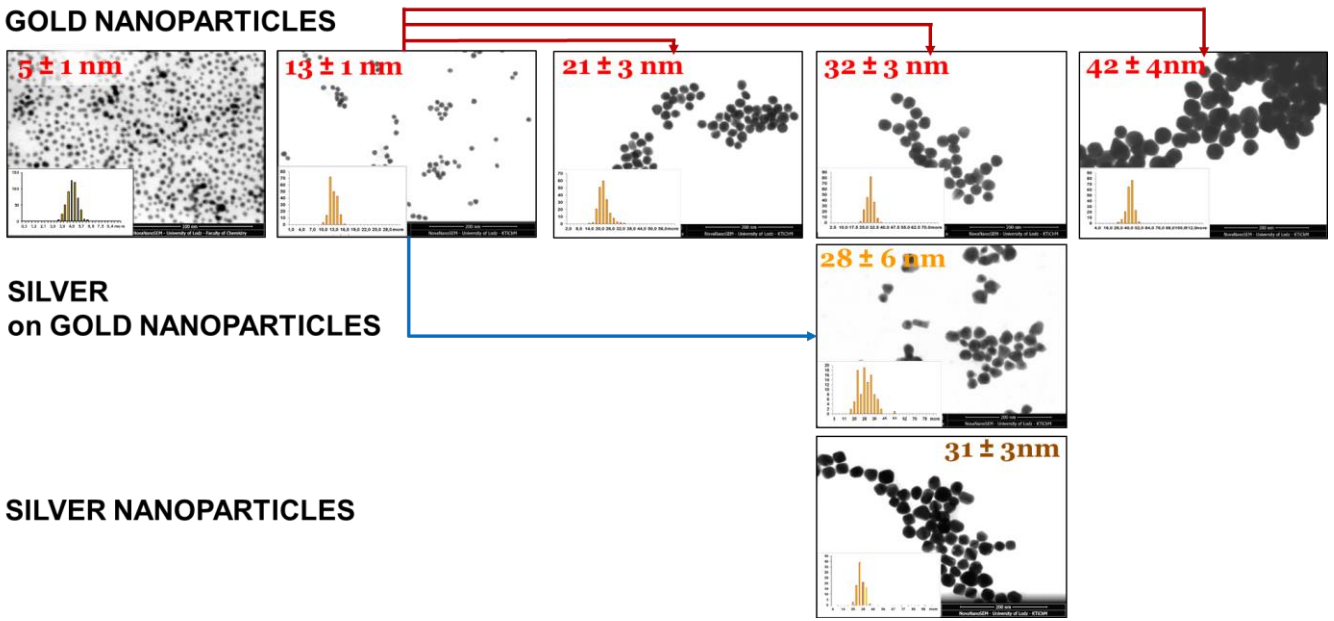
How to determine the amount of particles adsorbed on the nanoparticles surface?

Isothermal titration calorimetry (ITC) is a technique used to quantitatively study interactions between molecules. It directly measures the heat that is released or absorbed during bond formation. The measurement method allows to determine the binding affinity, stoichiometry, entropy and enthalpy of the bond formed between the reactants in the solution (e.g., binding stoichiometry, ΔH, ΔS, and ΔG).



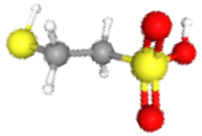


Materials determined using ITC

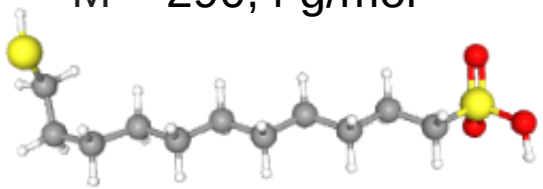


Precise knowledge of the metal mass in the colloid and the nanoparticles size allows to determine the molar concentration of nanoparticles and to estimate the surface area available for modification.

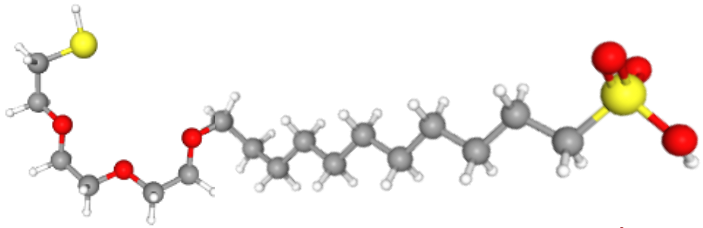
MES
Sodium methanethiolate
M = 164,18 g/mol



MUS
11-Mercaptoundecane-1-sulfonic acid sodium salt
M = 290,4 g/mol



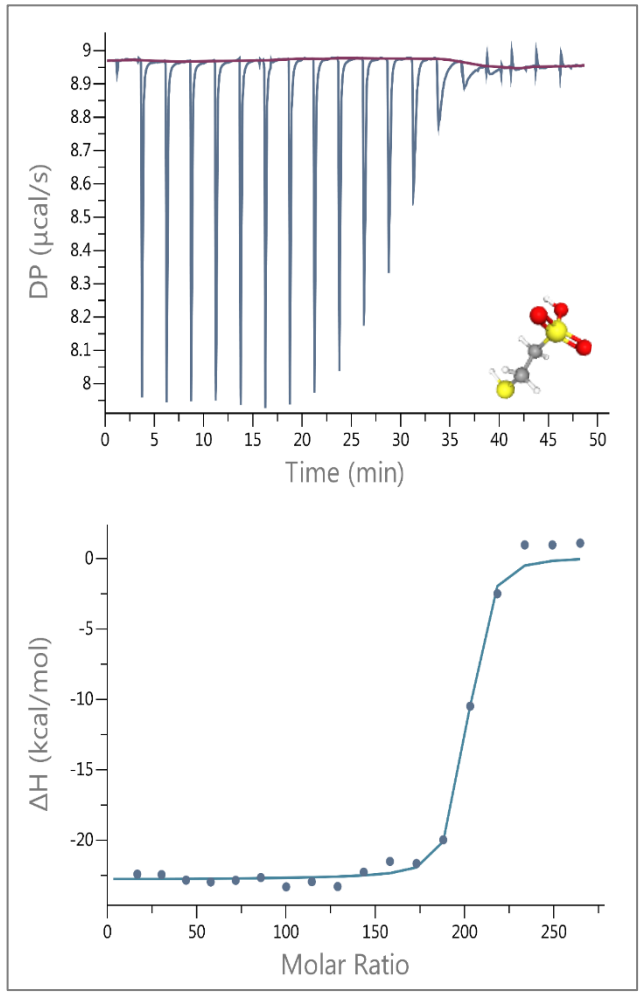
HS-PEG-SO_3Na
M = 422,58 g/mol



DIFFERENT LENGTH OF THE CARBON CHAIN

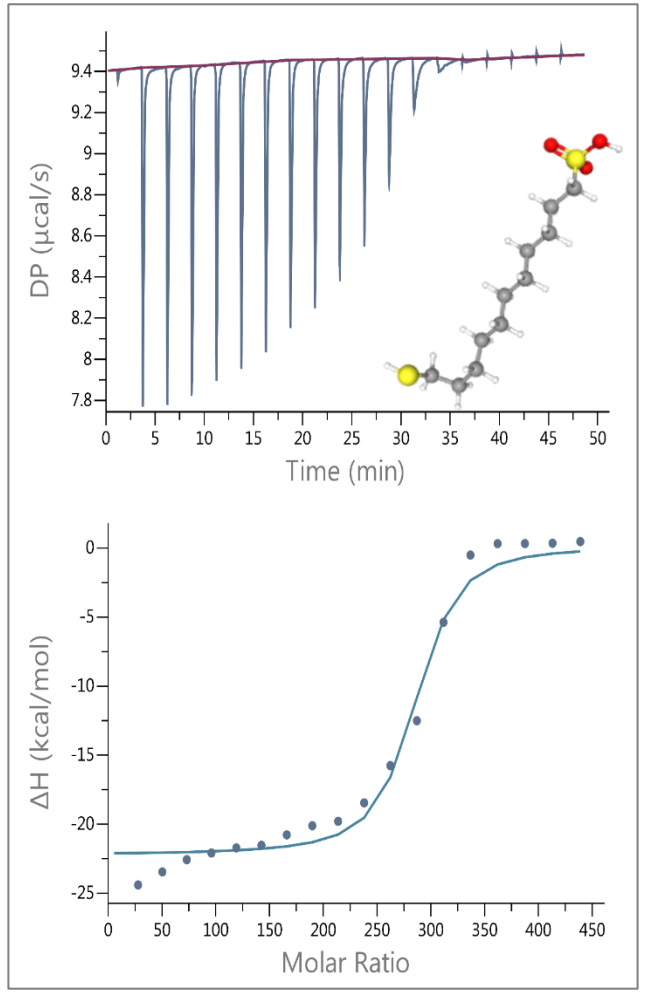
AuNPs_5 nm

MES



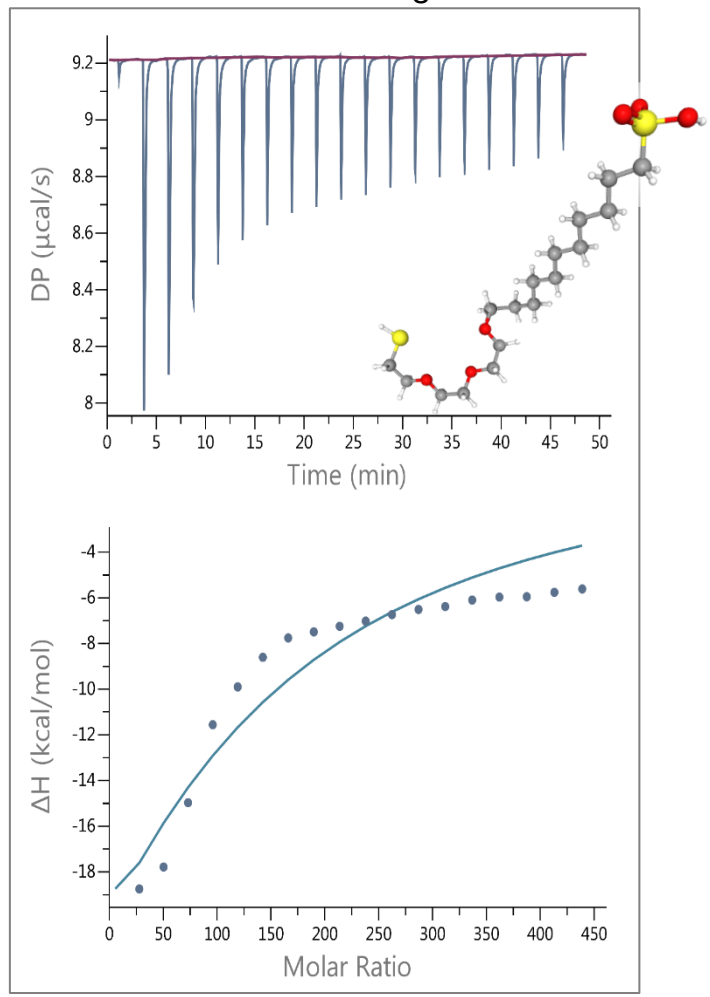
Surface coverage 203 molecules/NPs, that is 2,5 molecules/1 nm^2

MUS



Surface coverage 291 molecules/NPs, that is 3,5 molecules/1 nm^2

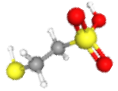
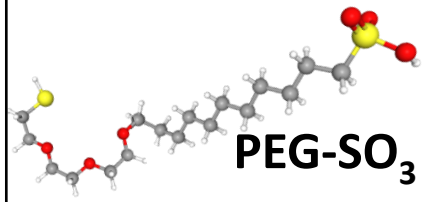
PEG-SO_3



Surface coverage 86 molecules/NPs, that is 1,25 molecules/1 nm^2

Obtained results for different sizes of nanoparticels

CALCULATED DEGREE OF COVERAGE [molecule/1nm^2]

	AuNPs_5nm	AuNPs_13nm	AuNPs_20nm	AuNPs_30nm	AuNPs_40nm
 **MES**	2,5	4	5	4,5	6,3
 **MUS**	3,5	5,25	6	5,5	8
 **PEG-SO_3**	1,25	**	**	**	**

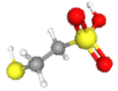
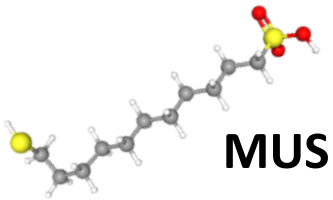
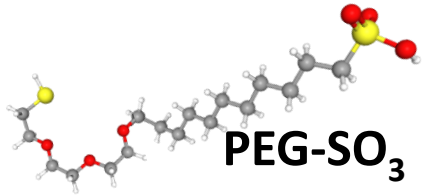
INCREASE IN DIAMETER

INCREASE IN THE NUMBER OF PARTICLES PER 1nm^2

** - at least two types of binding of molecules to the metal surface, results under analysis

Obtained results for different mettalic cores of nanoparticels

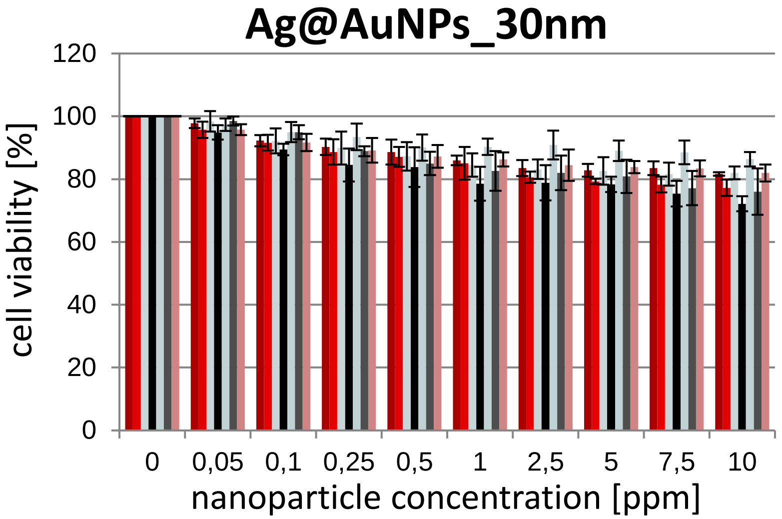
CALCULATED DEGREE OF COVERAGE [molecule/1nm^2]

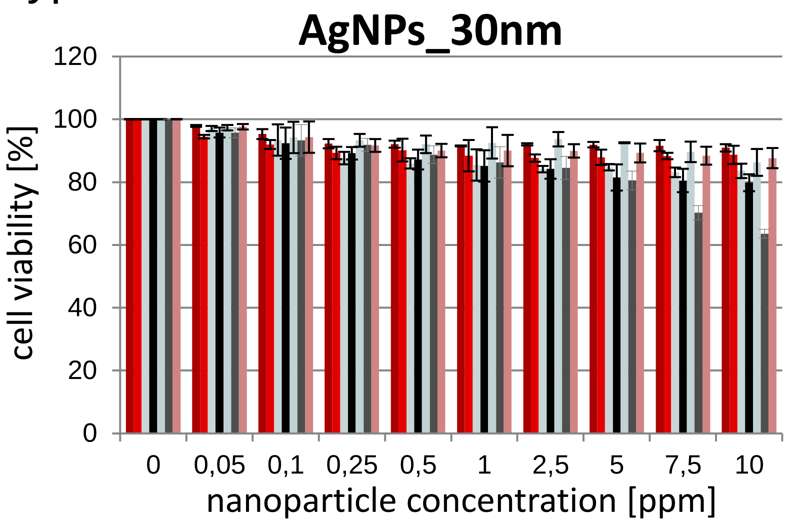
	AuNPs_30nm	Ag@AuNPs_30nm	AgNPs_30nm
 **MES**	4,5	2,7	2,5
 **MUS**	5,5	8,9	6,5
 **PEG-SO_3**	**	4,5	4,5

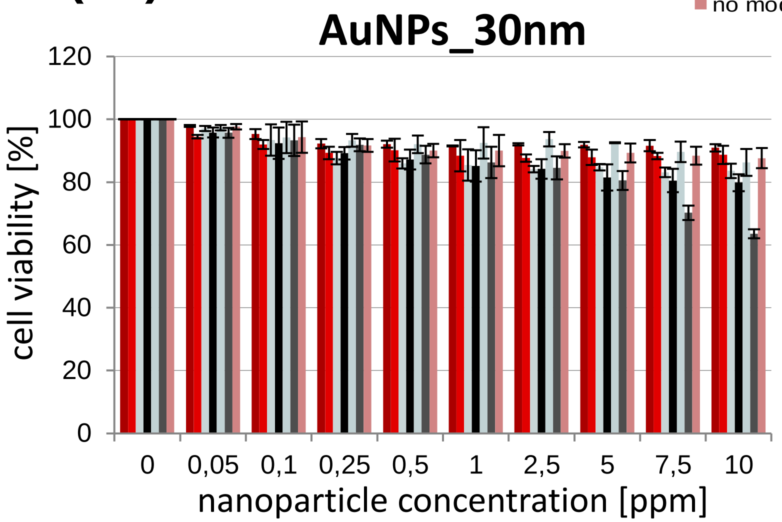
** - at least two types of binding of molecules to the metal surface, results under analysis

Biological activity test

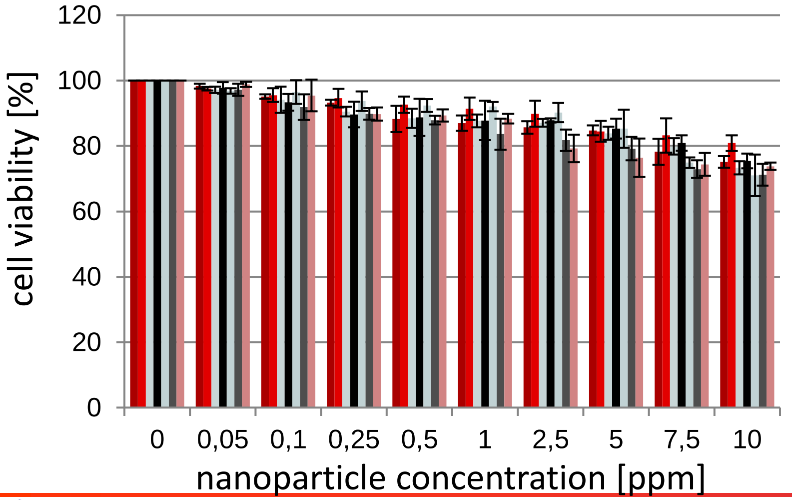
Cell type - **fibroblasts established from skin (BJ)**

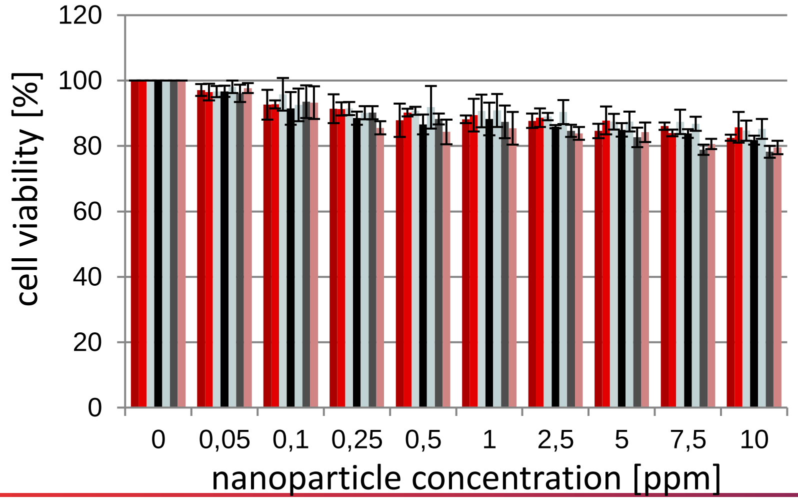


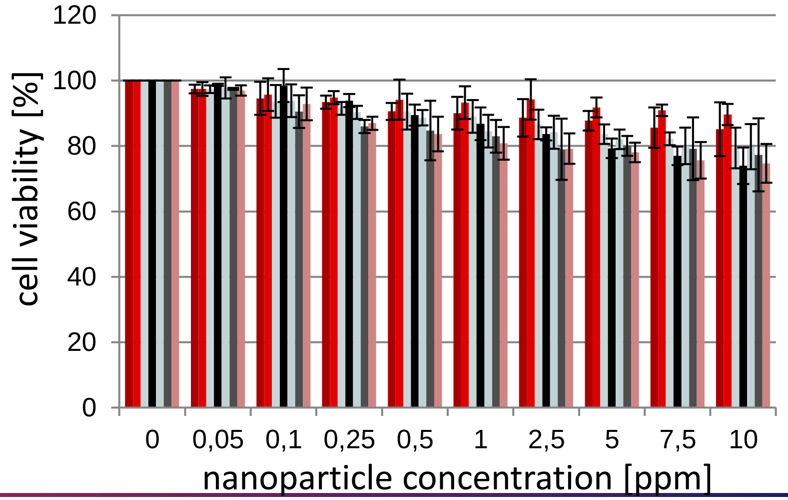




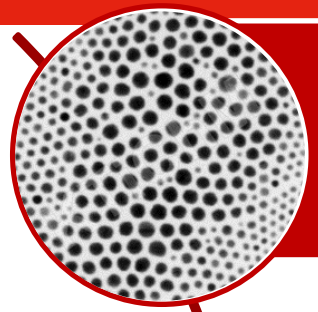
Cell type - **breast cancer cells (MCF7)**





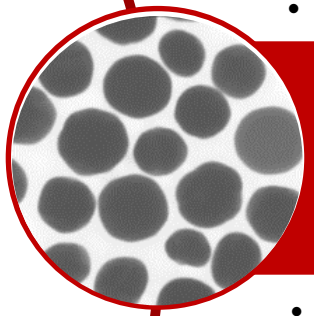


Summary



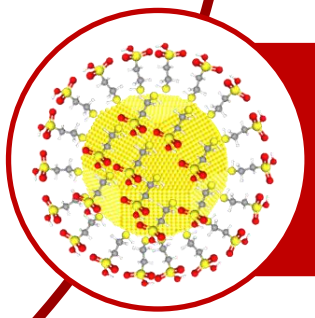
The obtaining of nanoparticles by chemical reduction method extended by the seed growth mediated synthesis leads to monodisperse colloids of metallic nanoparticles:

- AuNPs in size range 5 – 40 nm
- Ag@AuNPs in size about 30 nm
- AgNPs in size 30 nm



The ITC technique makes it possible to determine the degree of surface coverage of nanoparticles with thiol compounds:

- for colloids of gold nanoparticles, an increase in size was observed, resulting in an increase in the number of particles adsorbed per 1 nm^2
- the correlation between the structure of the metallic core and the amount of adsorbed molecules on the surface is difficult to describe



Knowledge of the amount of particles adsorbed on the metal surface opens the way to the conscious design of multifunctional nanoparticles

Acknowledgements

COST ACTION CA 17140
NANO2CLINIC
CANCER NANOMEDICINE - FROM THE BENCH TO THE BEDSIDE

cost
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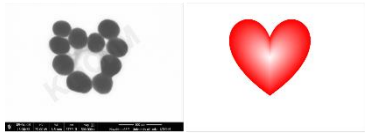
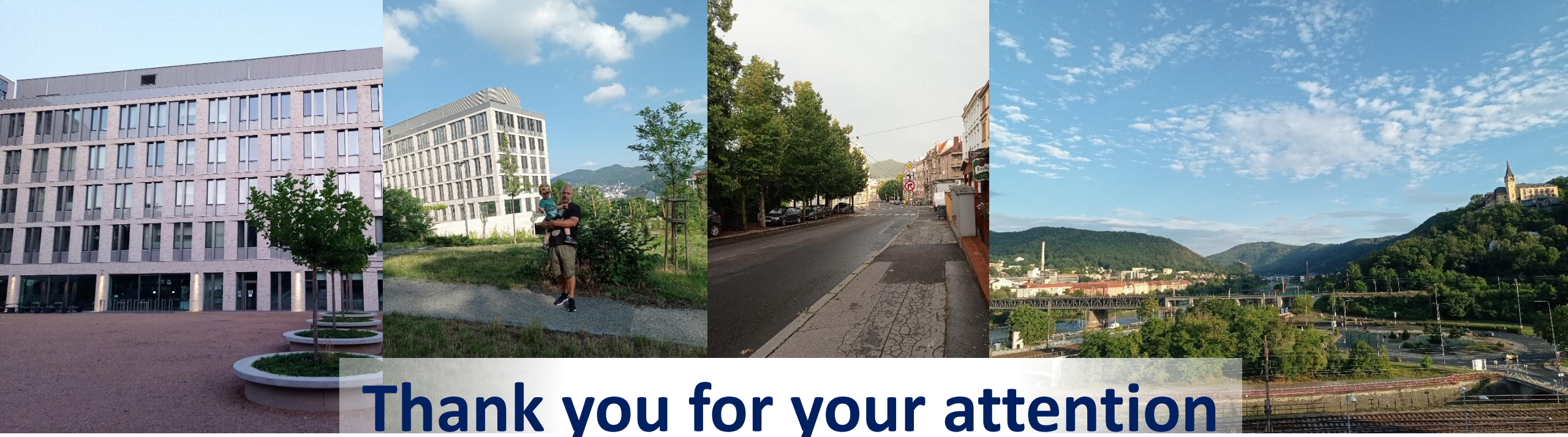
Faculty of Science, J.E. Purkyně University in Ústí nad Labem, Ústí nad Labem, Czechia

Special thanks go to PhD Dominika Wróbel



FACULTY OF CHEMISTRY
University of Lodz

I would also like to thank my colleagues from the team in which I work in the Department of MaterialsTechnology and Chemistry, Faculty of Chemistry, University of Lodz



Thank you for your attention