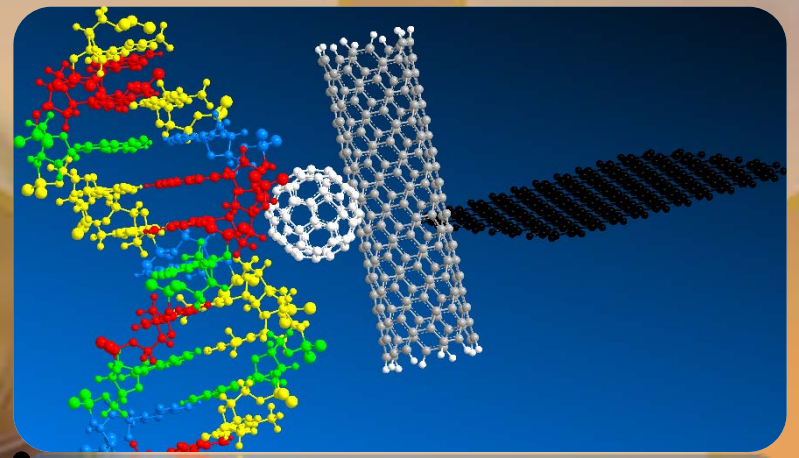


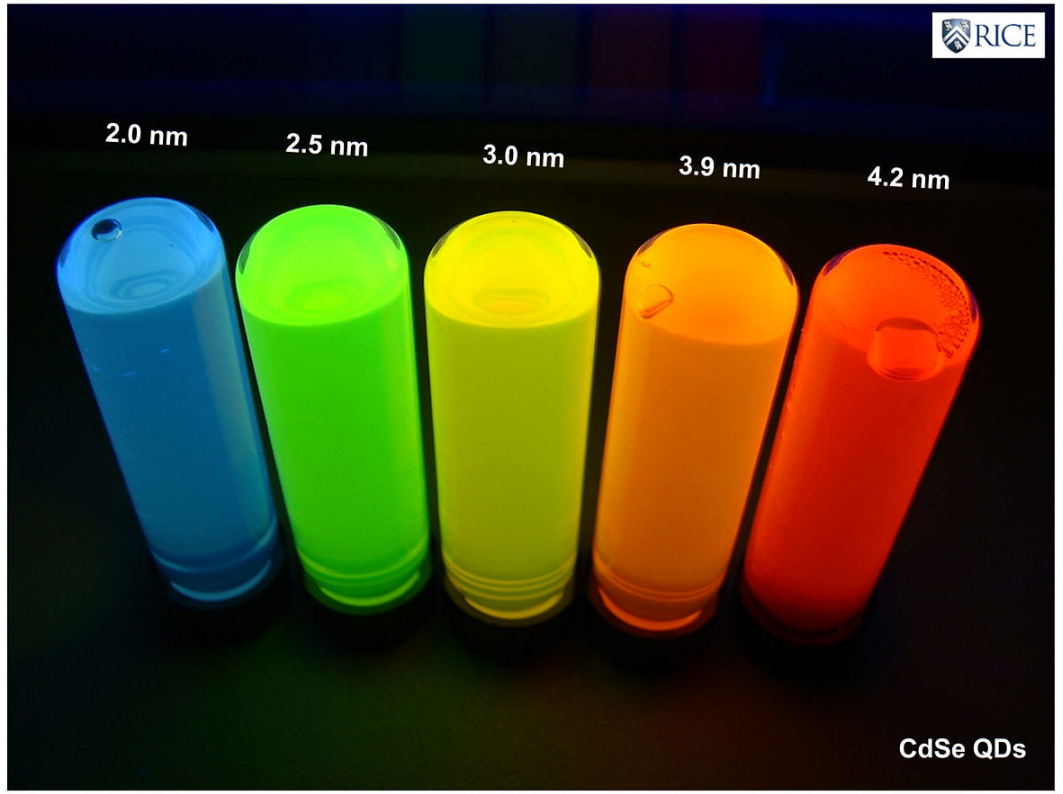
Bionanotechnologies and other application

From synthesis to device

PhD Antonino Cataldo
Marche Politechnic University
National Laboratory of Frascati

Nanoscale ma

n	Atom
1	13
2	55
3	147
4	309
5	561
7	1415
9	2869

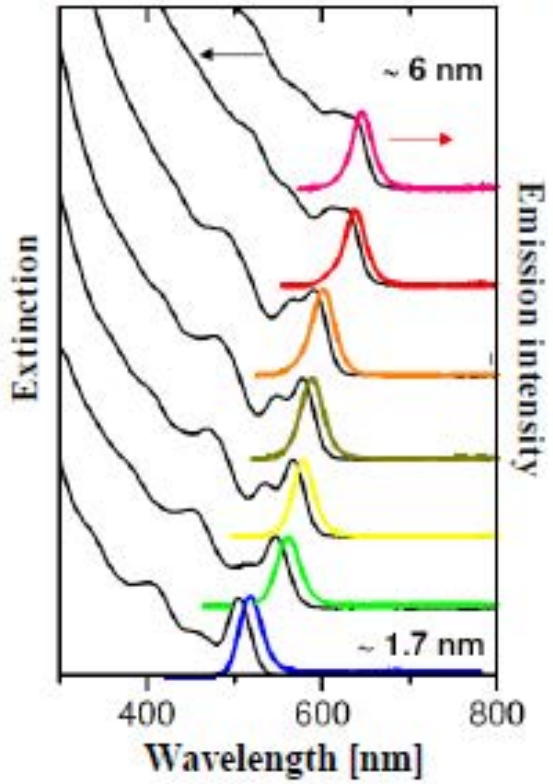


[1] MADKOUR, Loutfy H. Properties of Nanostructured Materials (NSMs) and Physicochemical Properties of (NPs). In: Nanoelectronic Materials. Springer, Cham, 2019. p. 479-564.
[2] Rice University, Prof. Michael S. Wong, https://commons.wikimedia.org/wiki/File:CdSe_Quantum_Dots.jpg

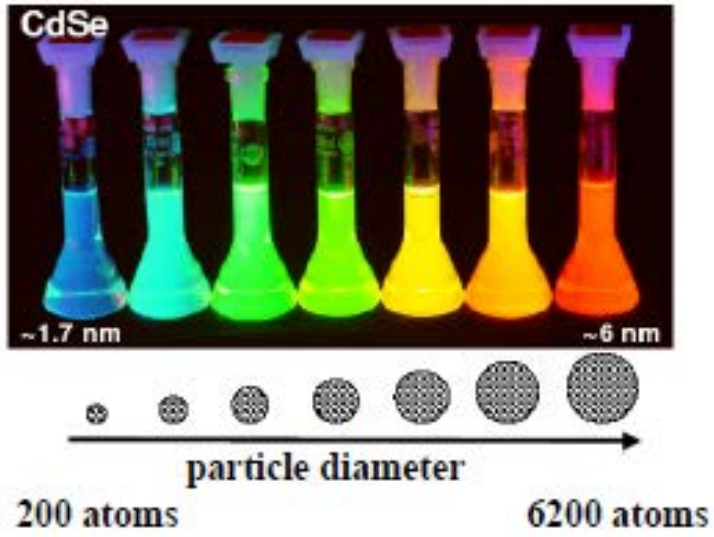
Nanoscale effect

CdSe Nanocrystals

Absorption and luminescence spectra



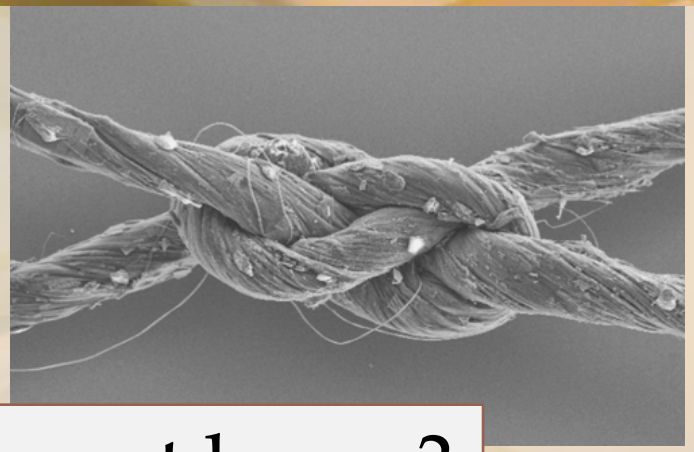
Colour under UV-A Excitation



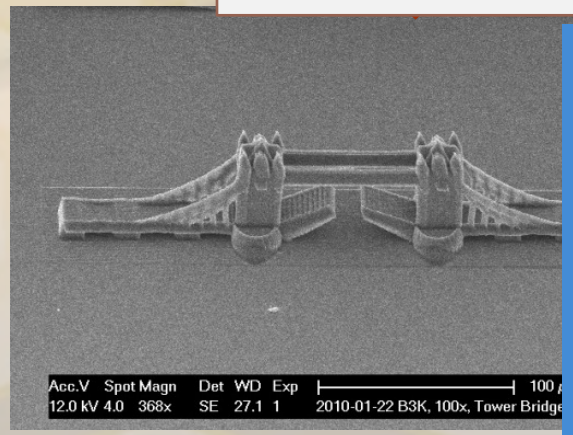
The size is important

How to do these materials?

"Top – Down"

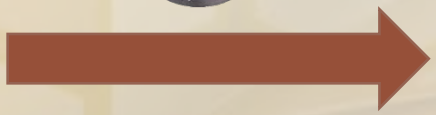


How can we prepare at home?

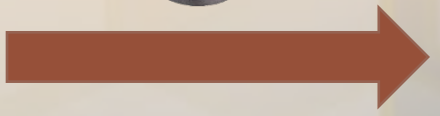


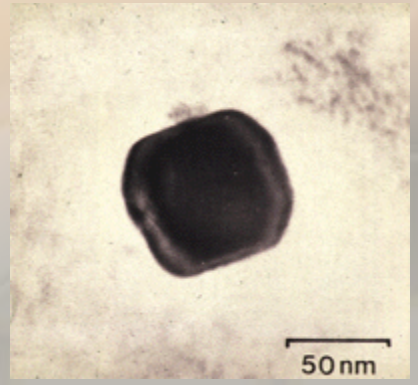
"Bottom - Up"

Basil Nanoparticles? Or…

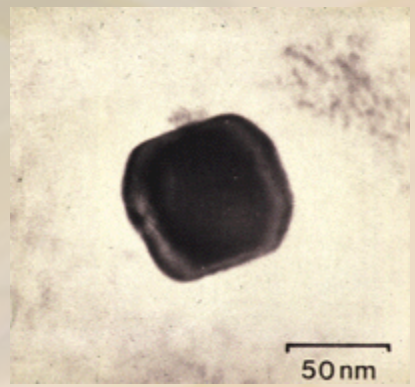


Or…





Ancient Nanoparticles



Licurgo's cup
(IV sec. d.C., British Museum)

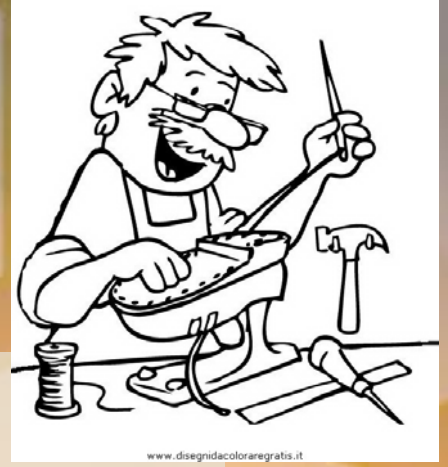
D. J. Barber e I. C. Freestone, «An investigation of the origin of the colour of the Lycurgus Cup by analytical transmission electron microscopy», *Archaeometry*, vol. 32, n. 1, pagg. 33–45, 1990

Ancient Nanoparticles

- Master Giorgio Andreoli from Gubbio (XV century)
  - Master potter specialized in Lustro technique (Lusterware)
- Lusterware: glaze gives waterproof and iridescence quality
- He specialized in two kinds of lustre reflections: an intense golden-yellow and a ruby-red colour

G. Padeletti *et al.*, «First-time observation of Mastro Giorgio masterpieces by means of non-destructive techniques», *Appl. Phys. A*, vol. 83, n. 4, pagg. 475–483, giu. 2006

Ancient Nanoparticles



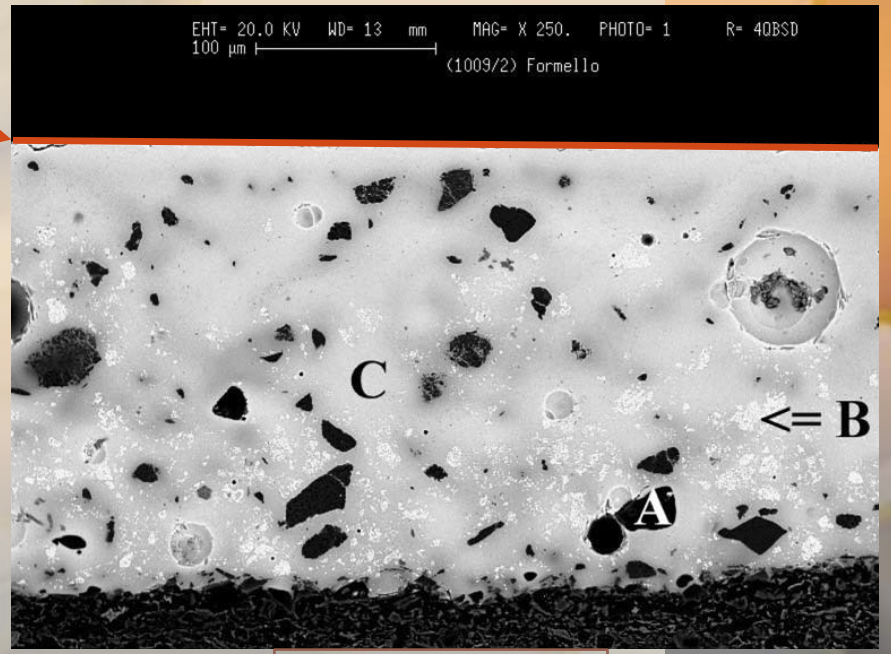
- An intense golden-yellow and a ruby-red colour:

Lustro

Thickness: 15/200 nm

Metallic nanoparticle: **Ag** and **Cu**

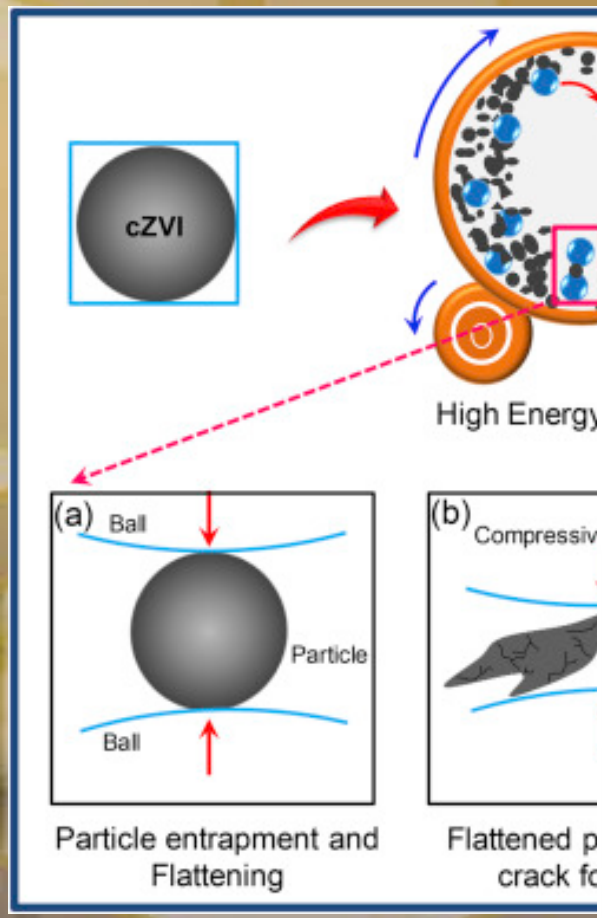
NP size ~100 nm

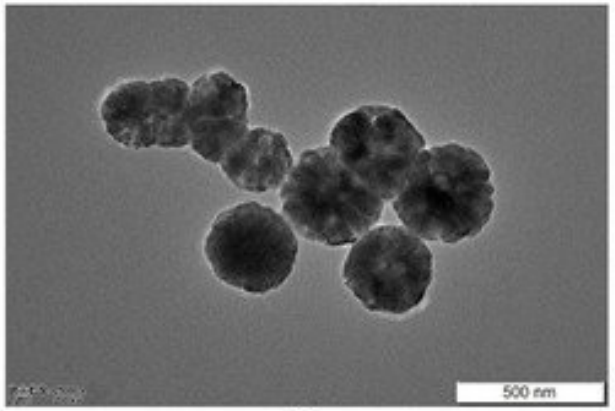


Cross section

G. Padeletti *et al.*, «First-time observation of Mastro Giorgio masterpieces by means of non-destructive techniques», *Appl. Phys. A*, vol. 83, n. 4, pagg. 475–483, giu. 2006

Top-Do

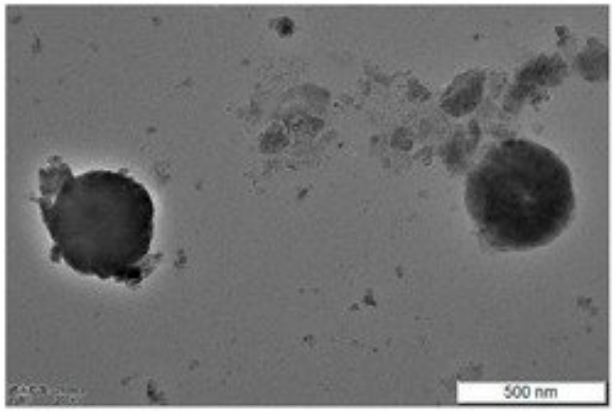




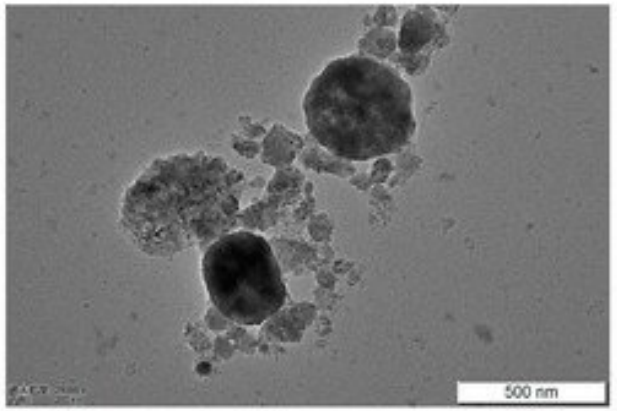
(a)

t=0

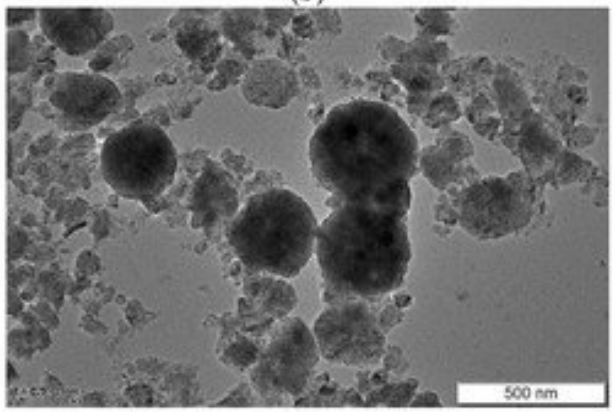
Δt=30min



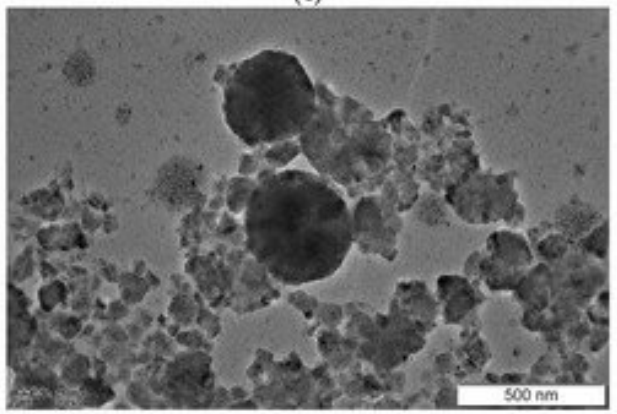
(b)



(c)



(d)



(e)

o nanocrystallites

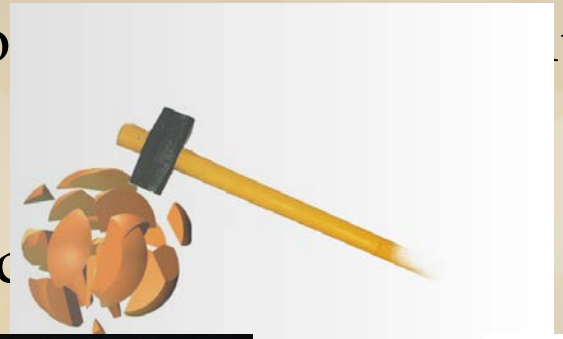
ill being used as part of a gold mining operation in Peru

AMBIKA erization

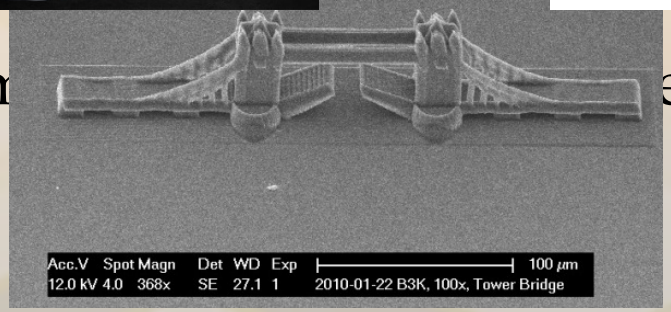
LIANG, Yi, et al. Effect of Ball Milling on the Absorption Properties of Fe3O4. *Materials*, 2020, 13.4: 883.

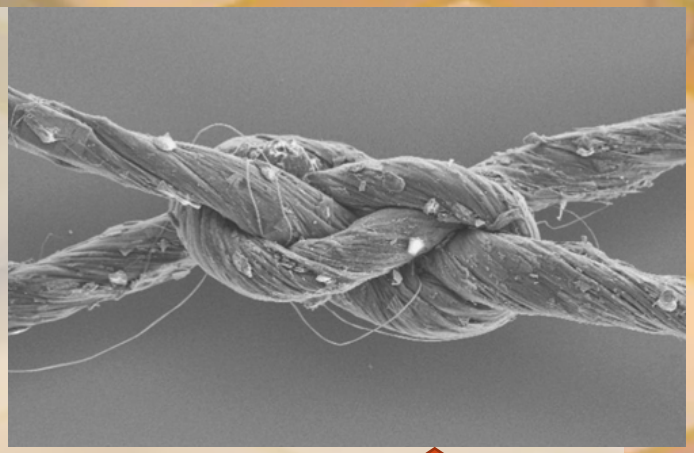
How to do these materials?

- How to tter at atomic scale?
- By hand
- Chem ecial reactors?



op – Dov



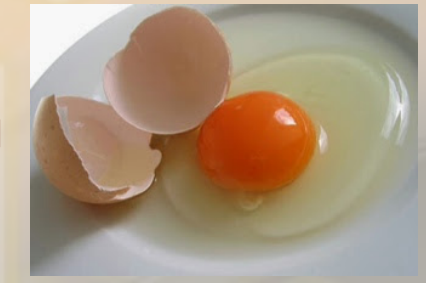


"Bottom - Up"

Credit: Shutterstock

Household Bottom-Up approach

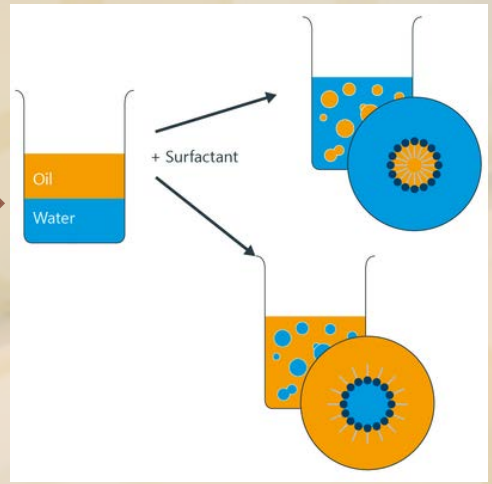
but

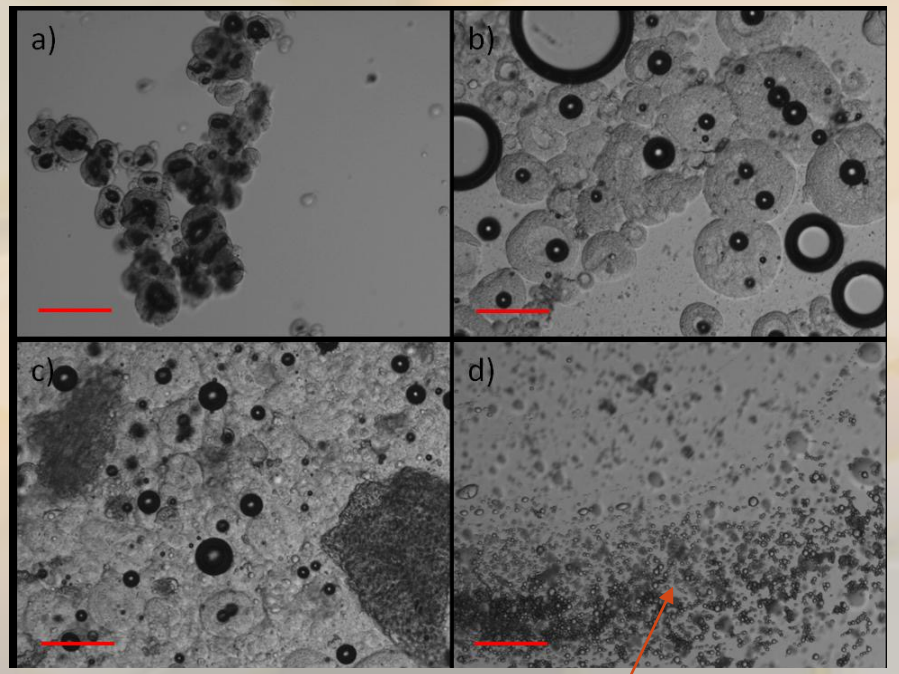


Household Bottom-Up approach

- W/O or O/W instable dispersion

Emulsion





Oil droplets (size 10^{-6} m range)

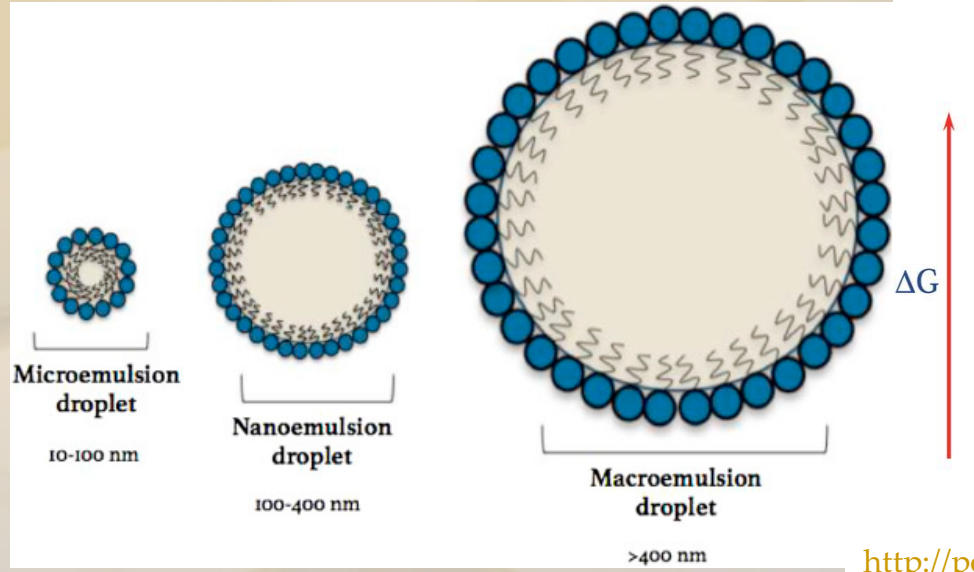
We need tiny, stable reactors
We need…

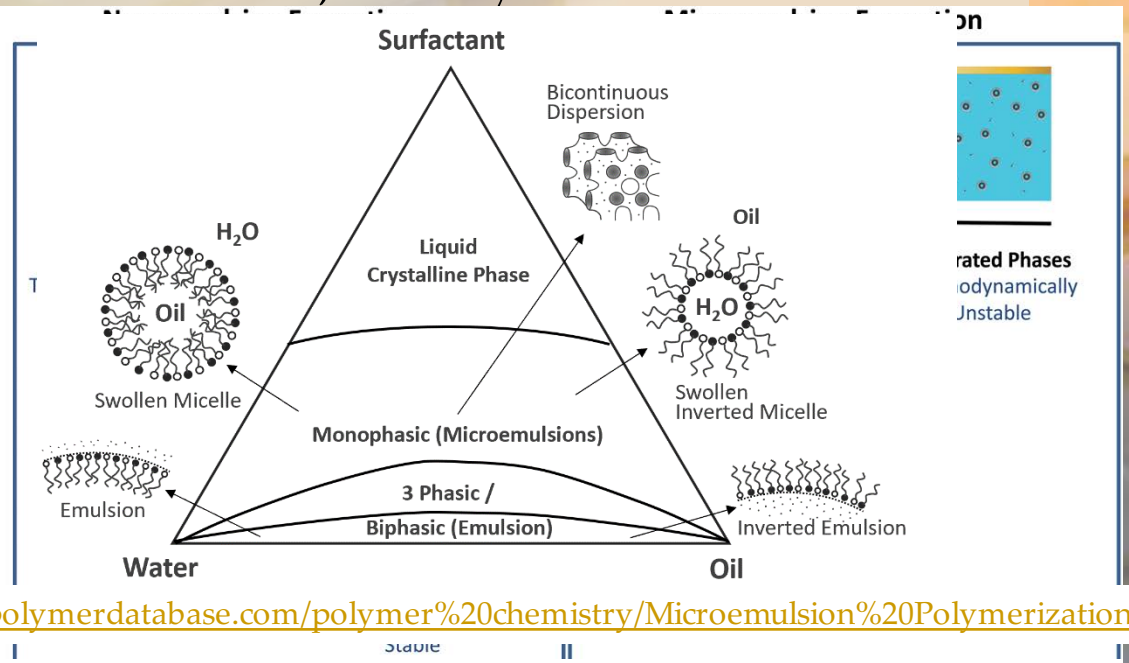
WIDERSTRÖM, Ebba; ÖHMAN, Rebecca. Mayonnaise: Quality and Catastrophic Phase Inversion. 2017.

https://www.kruss-scientific.com/services/education-theory/glossary/emulsion/

Bottom-Up approach : Synthesis in Microemulsion

- Microemulsion
  - Dispersion made of water, oil, and surfactant(s) that is an isotropic and thermodynamically stable system with dispersed domain diameter varying approximately from 1 to 100 nm, usually 10 to 50 nm.



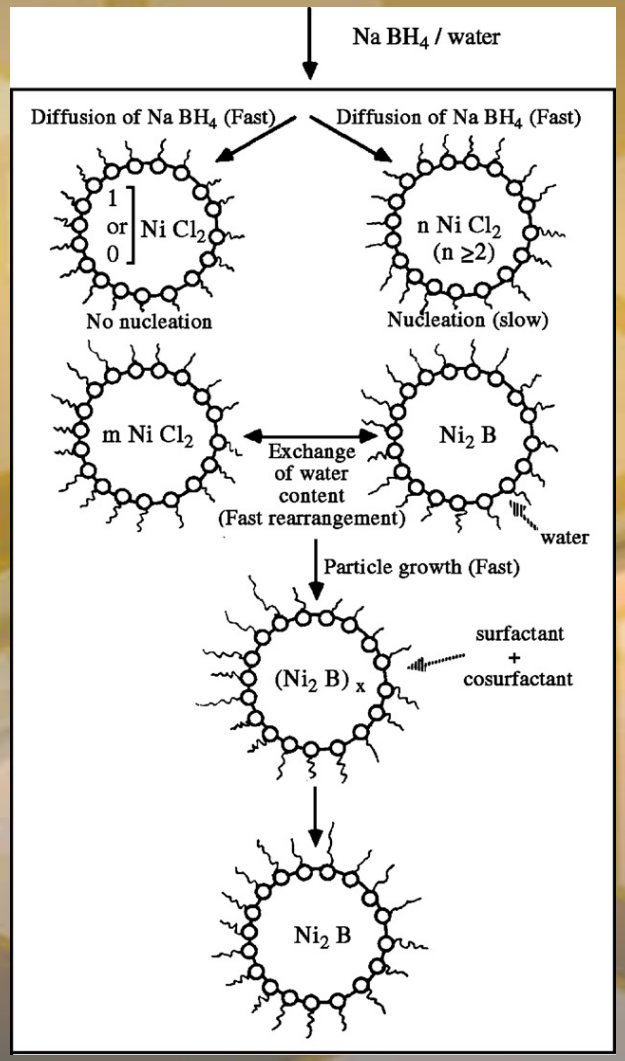


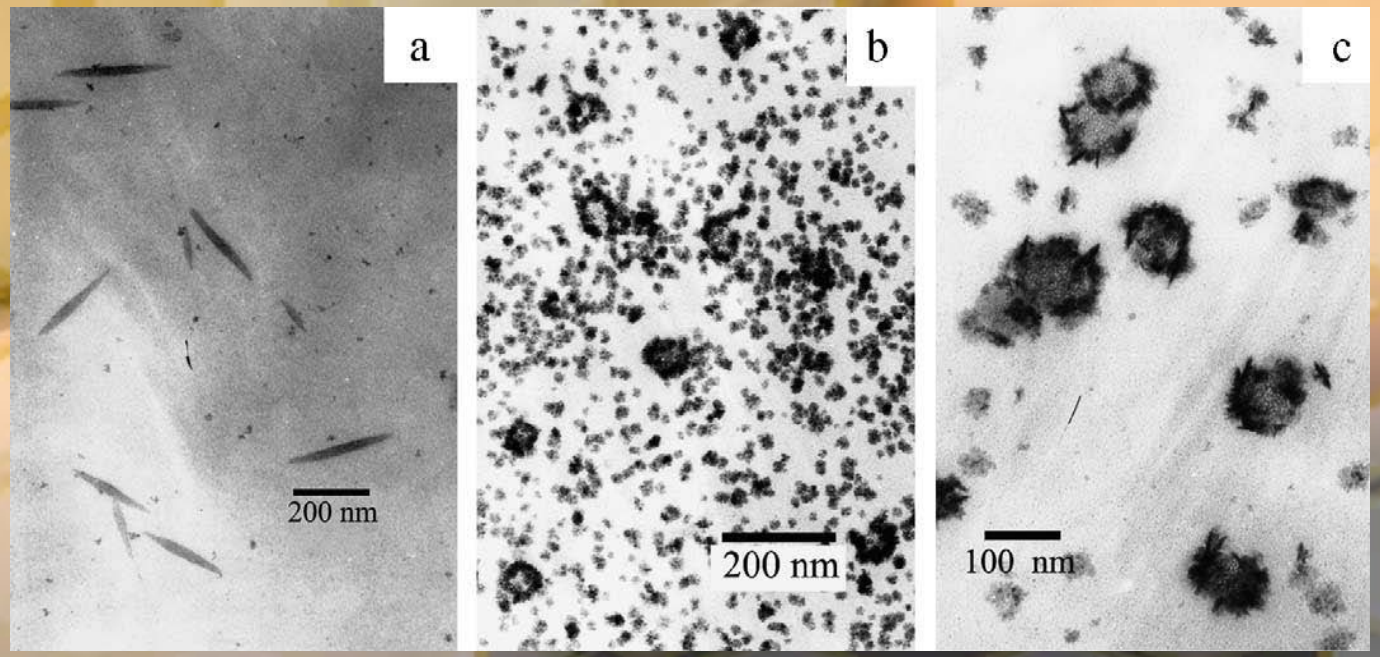
http://polymerdatabase.com/polymer%20chemistry/Microemulsion%20Polymerization.html

McClements, David Julian. "Nanoemulsions versus microemulsions: terminology, differences, and similarities." Soft matter 8.6 (2012): 1719-1729.

SLOMKOWSKI, Stanislaw, et al. Terminology of polymers and polymeri… …euticals: processes in dispersed systems (IUPAC Recommendations 2011). *Pure ar… Applied Chemistry*, 2011, 83.12: 2229-2259.

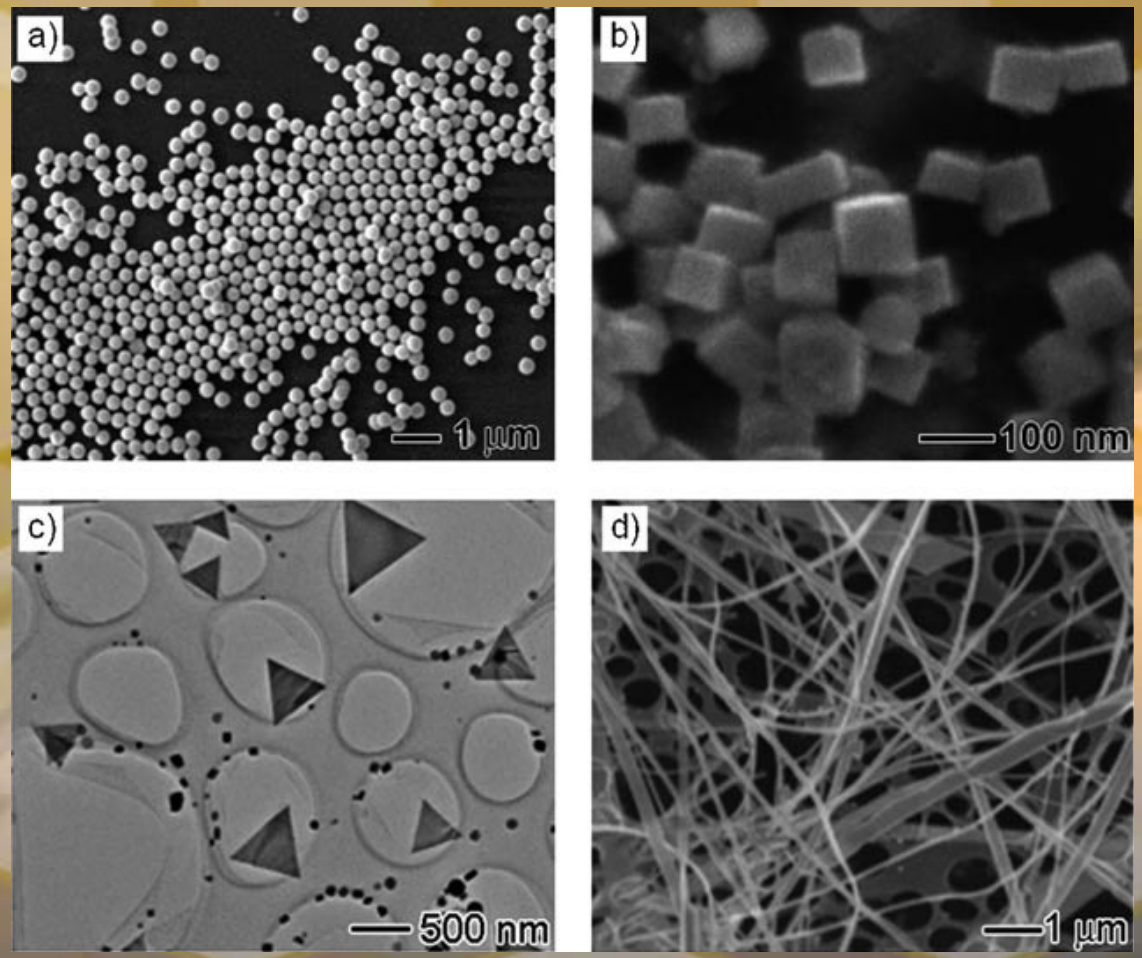
Bottom-Up approach : Synthesis in Microemulsion



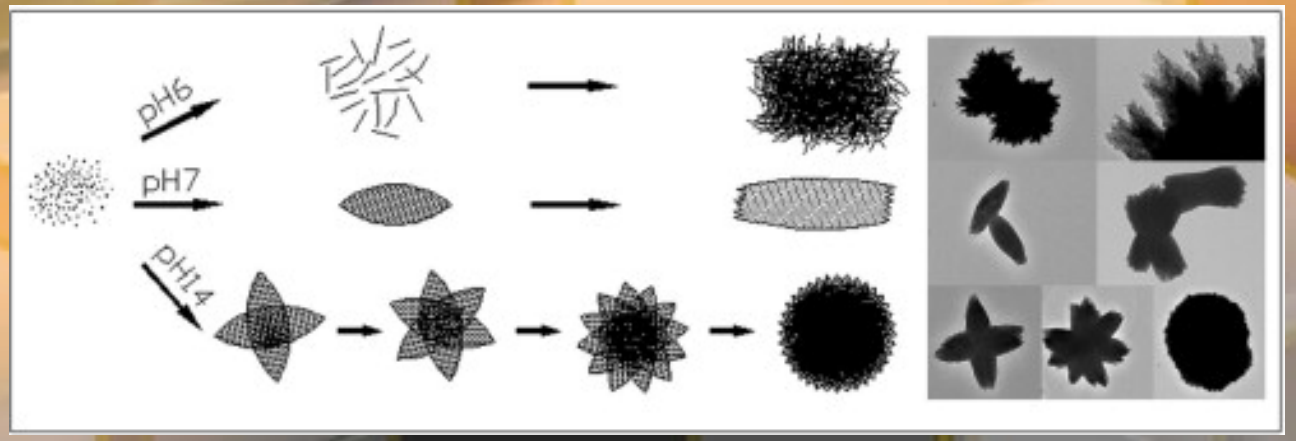


Charinpanitkul, Tawatchai, et al. "Effects of cosurfactant on ZnS nanoparticle synthesis in microemulsion." *Science and Technology of Advanced Materials* 6.3-4 (2005): 266.

Bottom-Up approach



Xia, Younan, et al. "Shape-controlled synthesis of metal nanocrystals: simple chemistry meets complex physics?." *Angewandte Chemie International Edition* 48.1 (2009): 60-103.

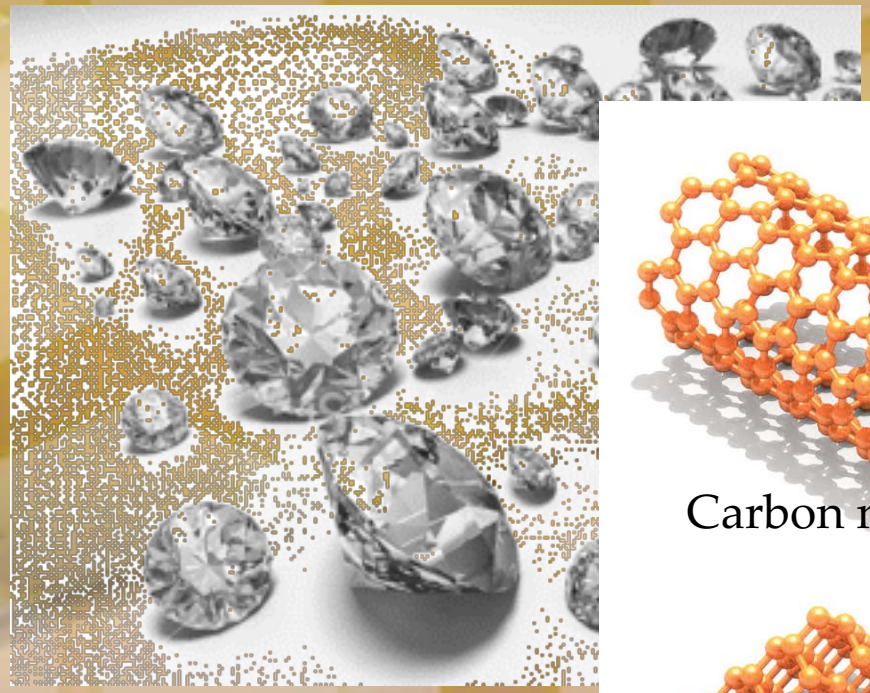


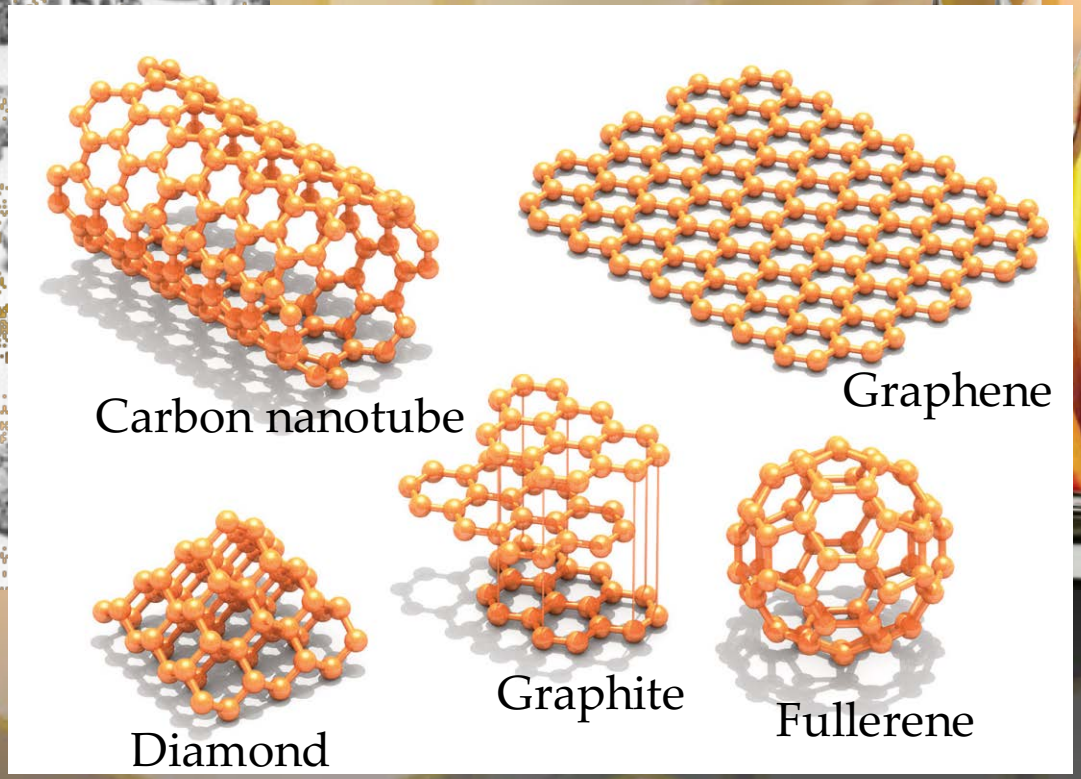
Yang, Linlin, et al. "Shape-controlled of CaWO4 microcrystals by self-assembly of nanocrystals via a simple sonochemical method." Advanced Powder Technology 24.3 (2013): 721-726.

Time for questions

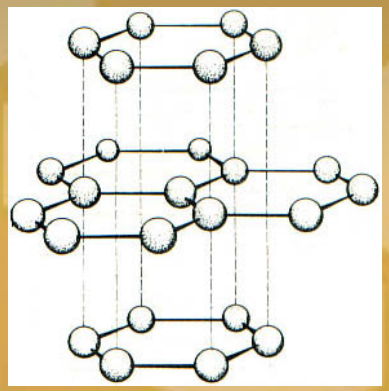
Credit: Shutterstock

What we do in lab: Carbon Nanostructures

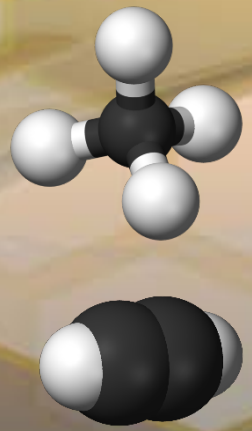


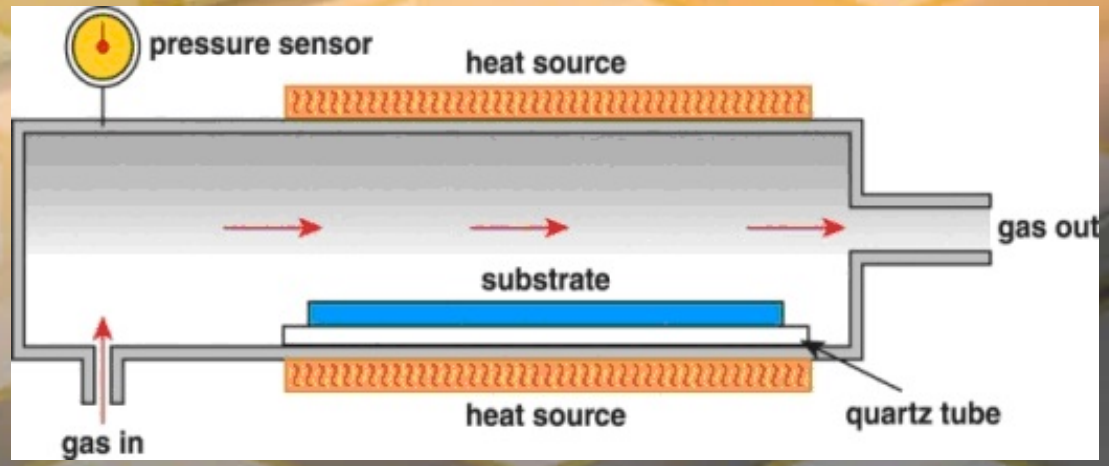


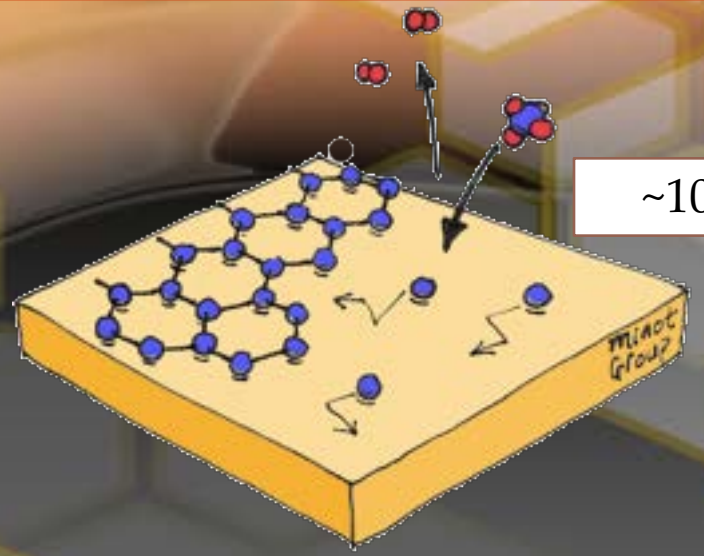
What we do in lab: Graphene



Scotch tape method

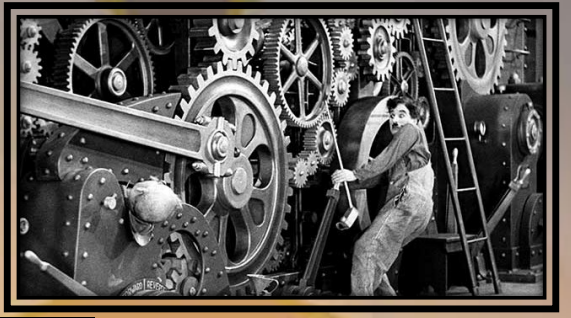


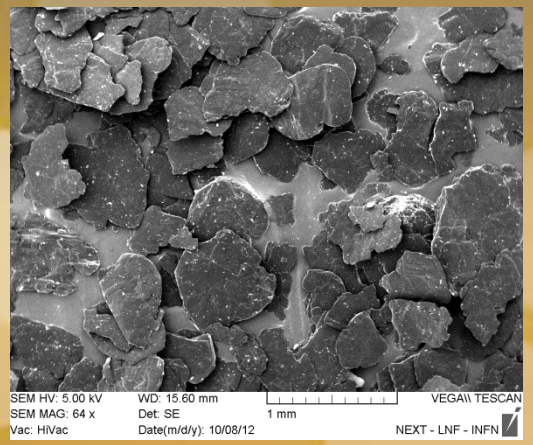


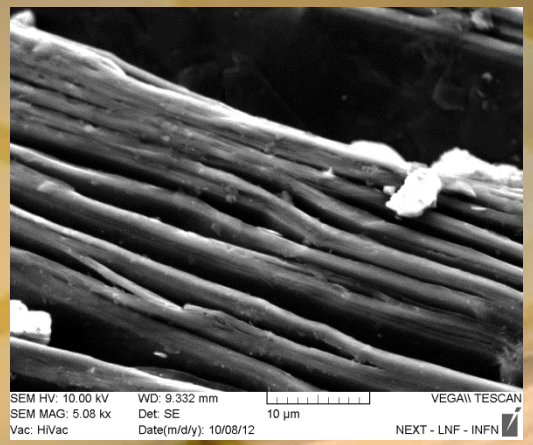


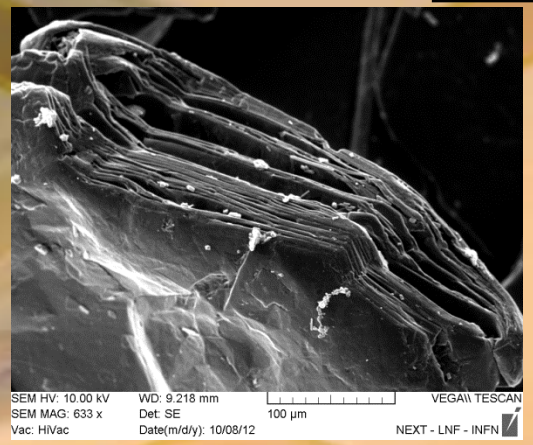
Chemical Vapor deposition (CVD)

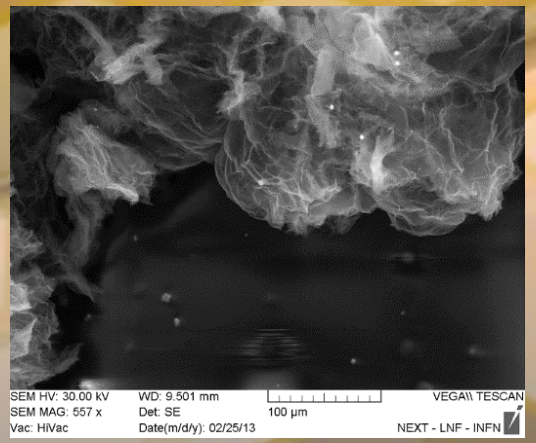
Graphene nanoplates preparation assisted by microwave

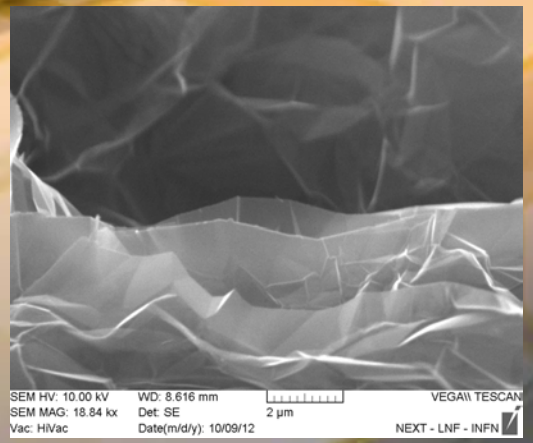


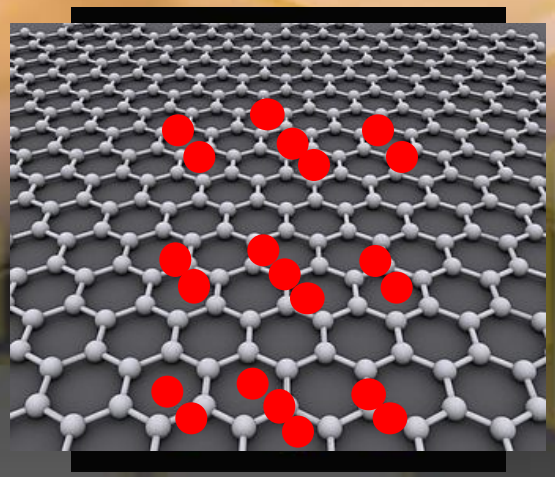










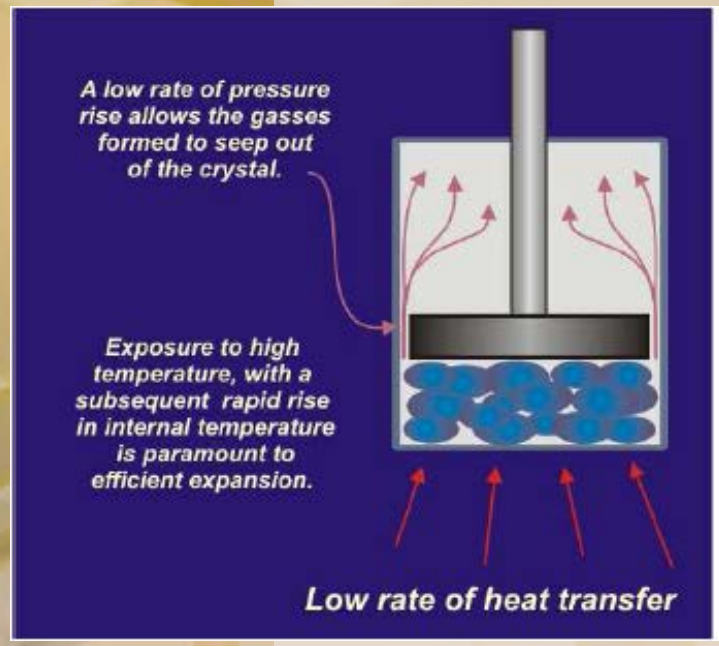


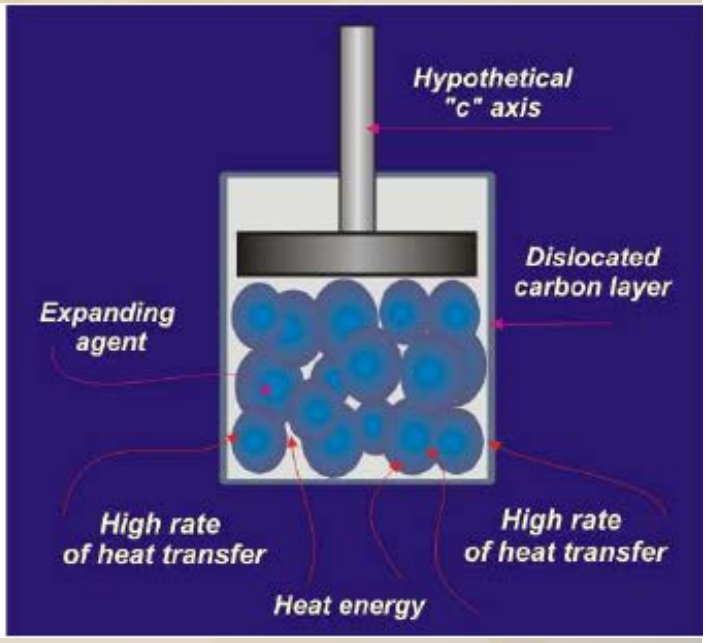
A. Maffucci, F. Micciulla, A. Cataldo, G. Miano and S. Bellucci, *Nanotechnology*, 2016, **27**, 095204

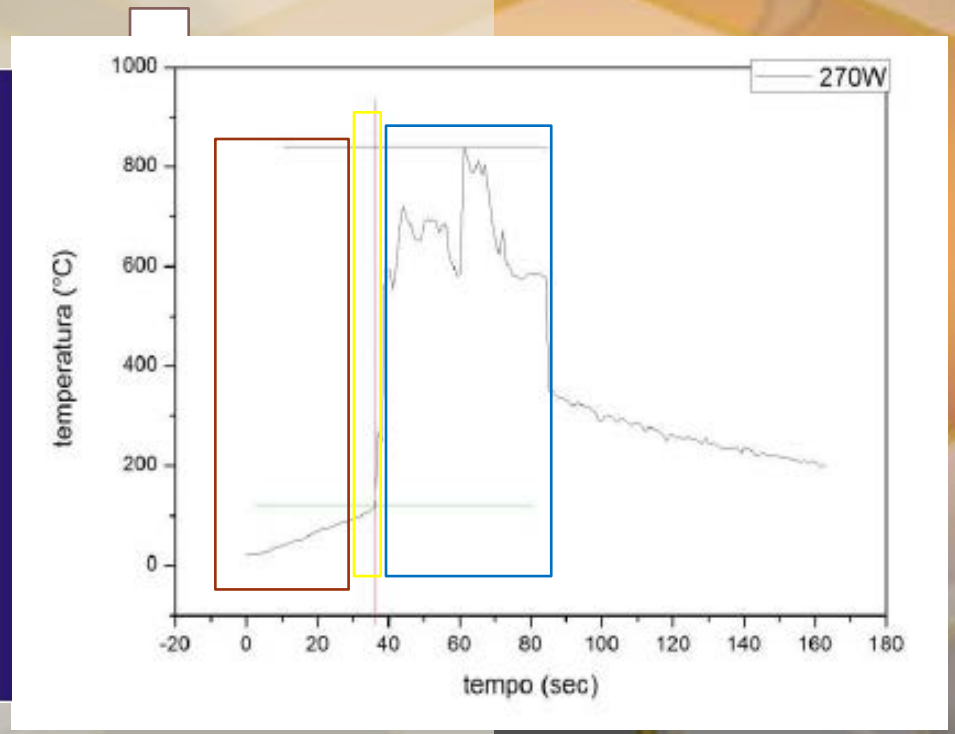
S. Bellucci, M. Bozzi, A. Cataldo, R. Moro, D. Mencarelli and L. Pierantoni, in Semiconductor Conference (CAS), 2014 International, IEEE, 2014, pp. 17–20

Graphene nanoplates preparation(MW) Setup and mechanism of synthesis

- 2 important parameters

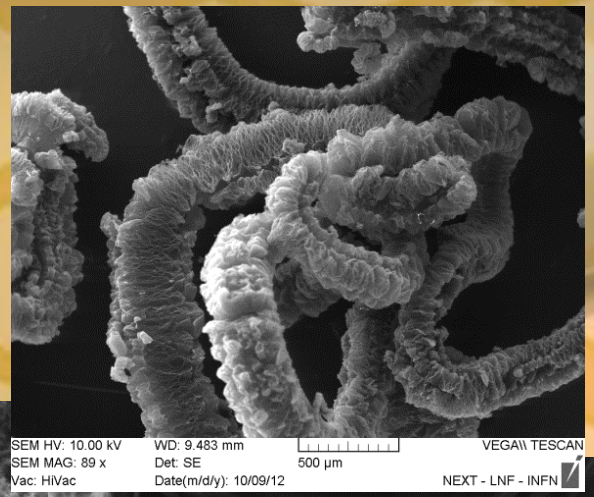


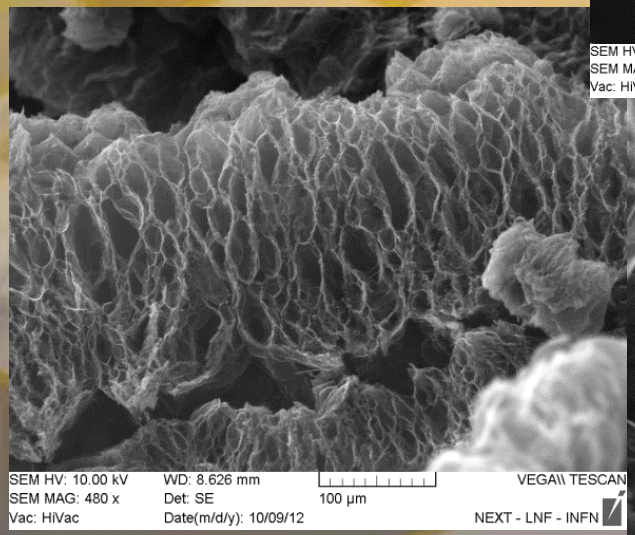


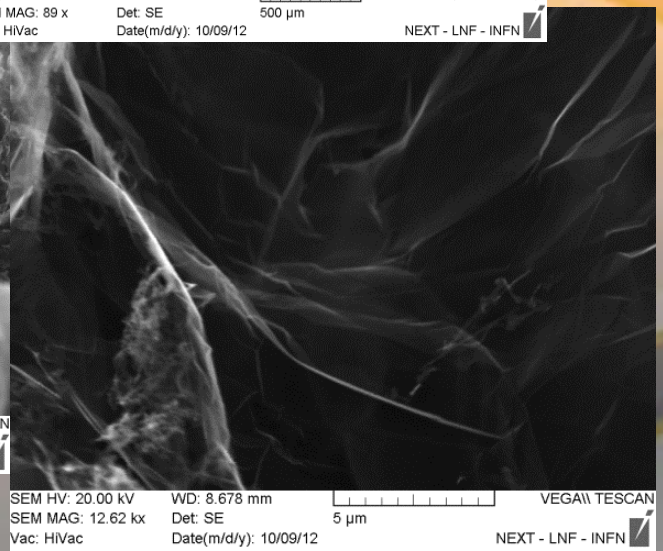


Electronic Microscopy

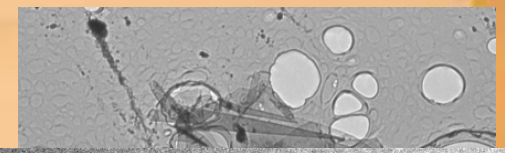
Scanning Electronic Microscopy (SEM)

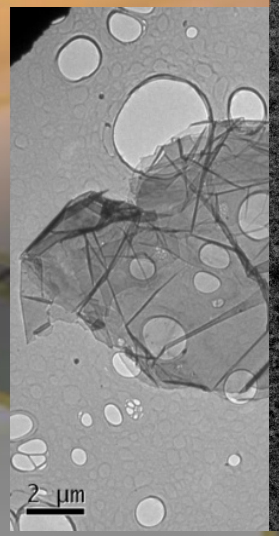


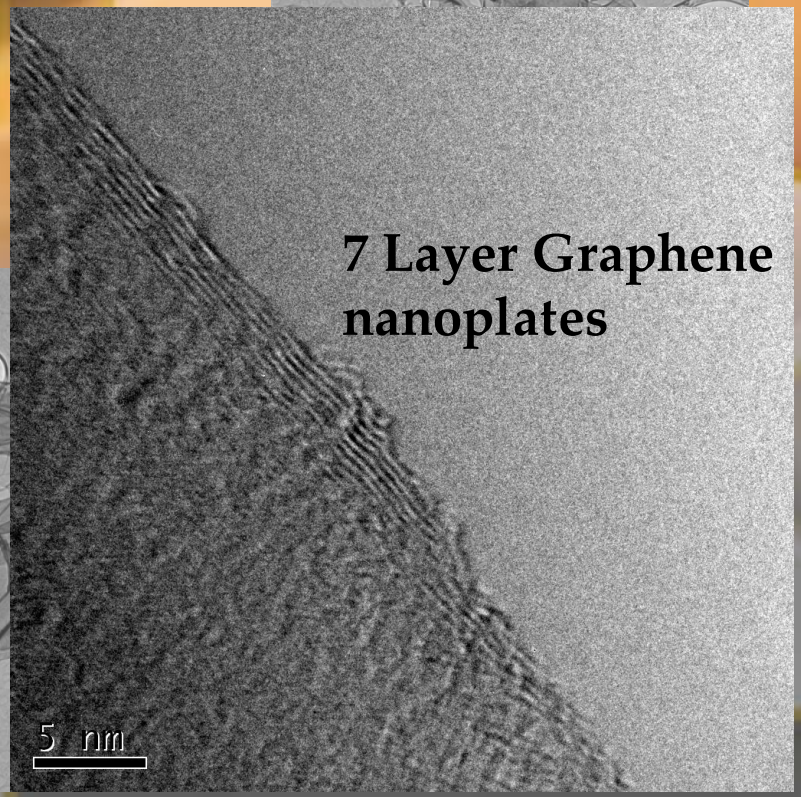




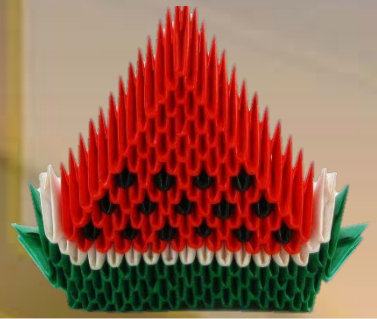
Transmission Electron Microscopy (TEM)







Graphene paper

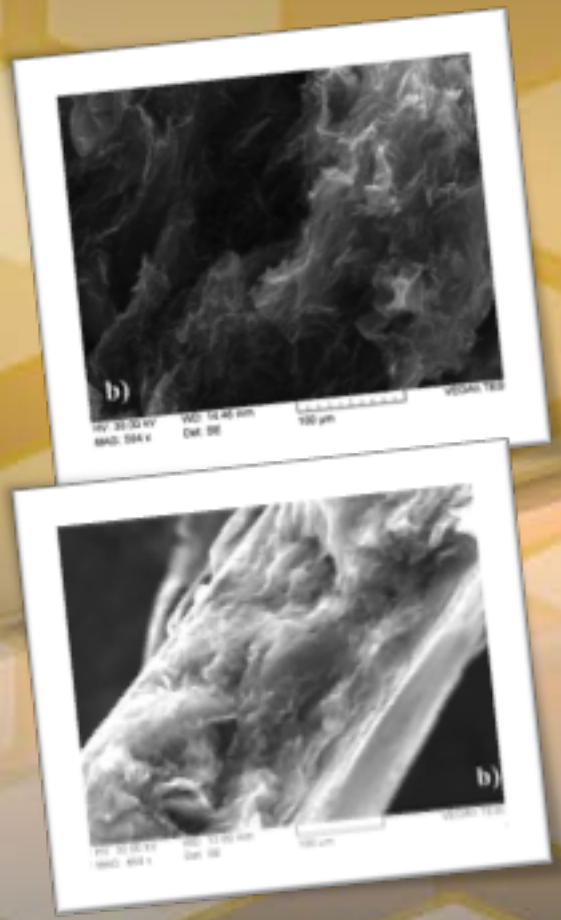


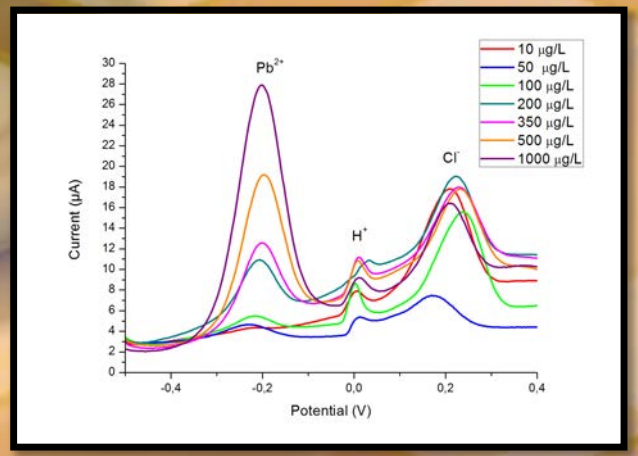
- Similar to buckypaper

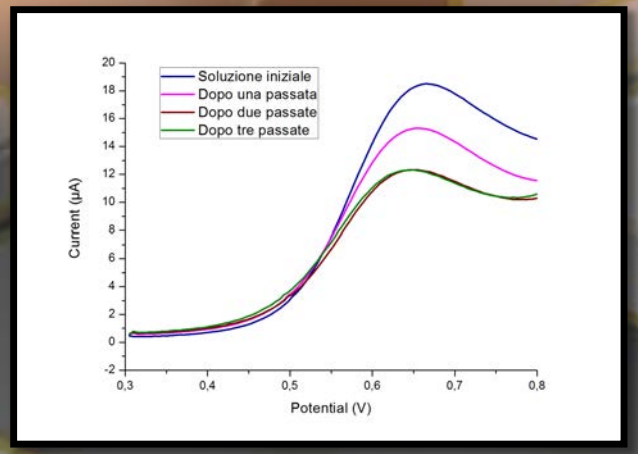
Electrical and thermal conductor, hydrofobic material

video

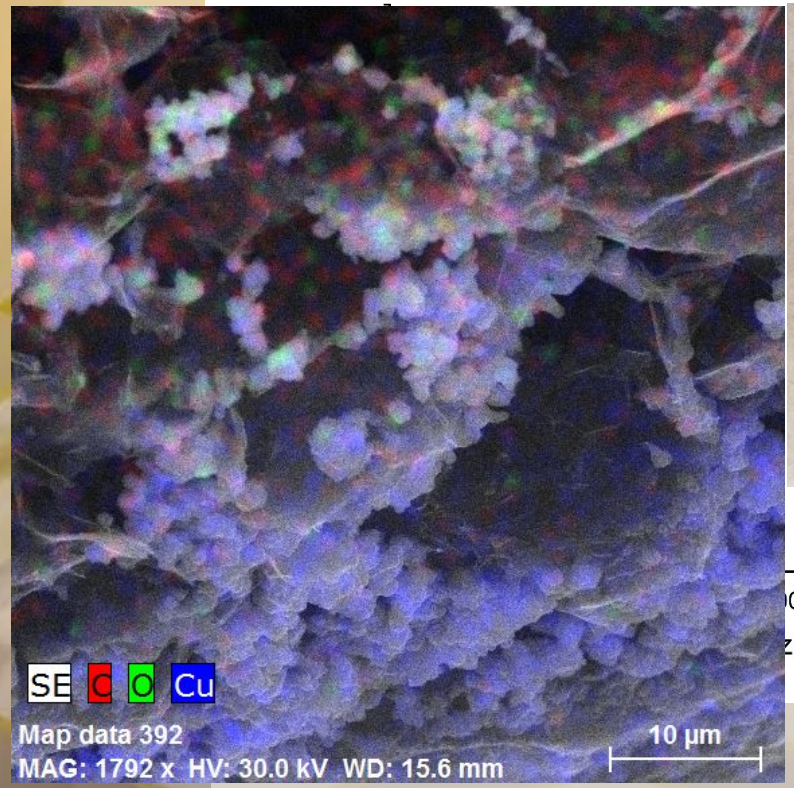
Graphene paper: environmental remediation

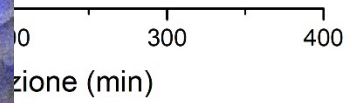


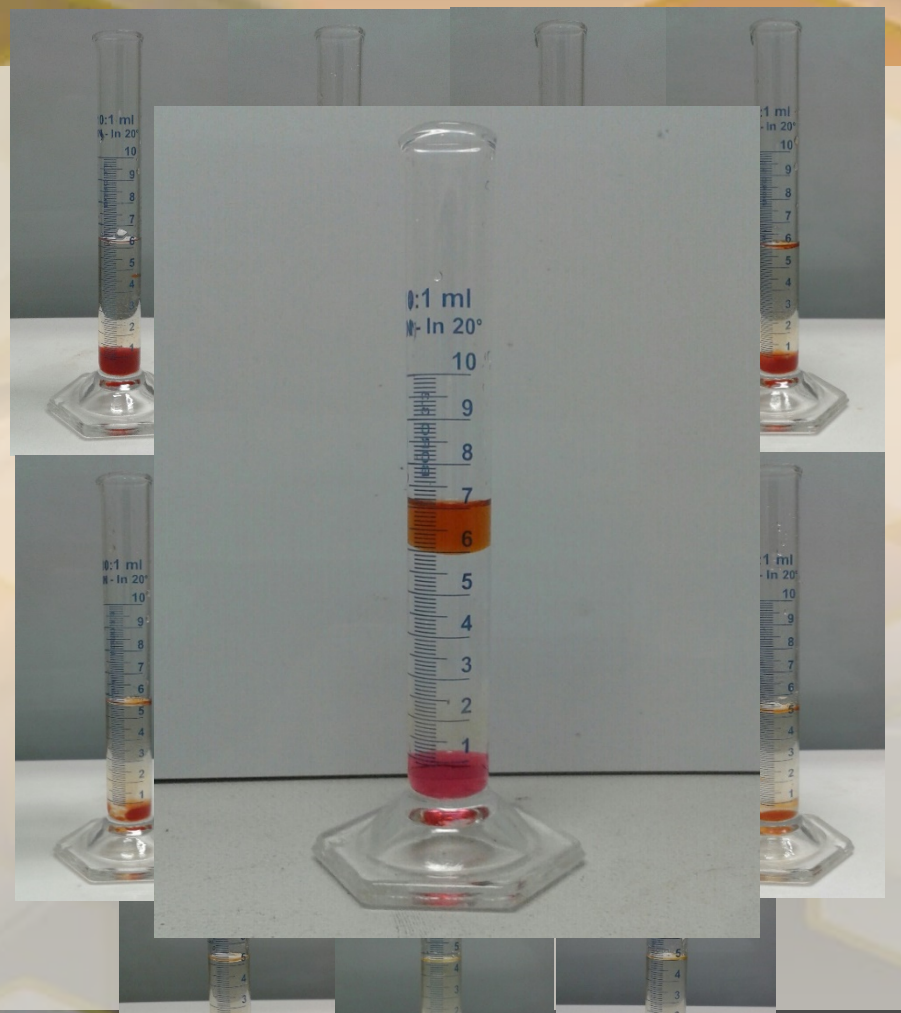




Graphene paper: environmental remediation



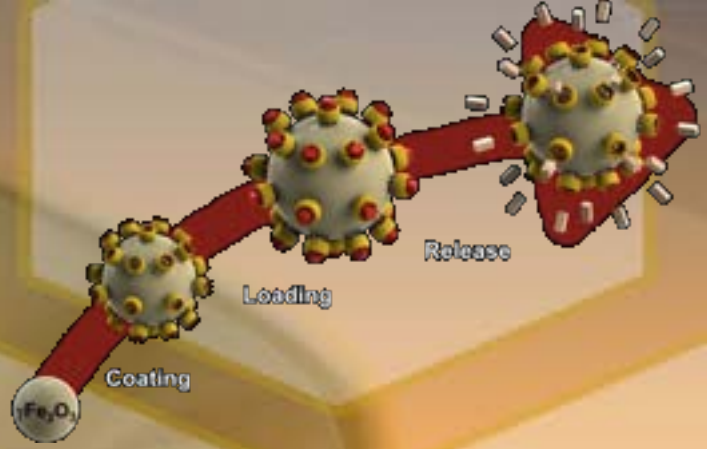


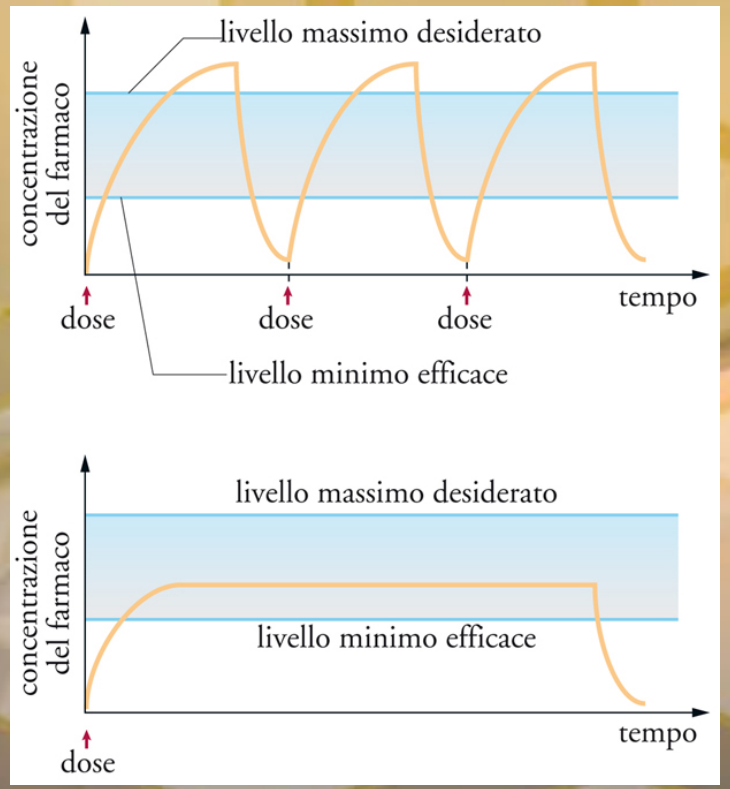


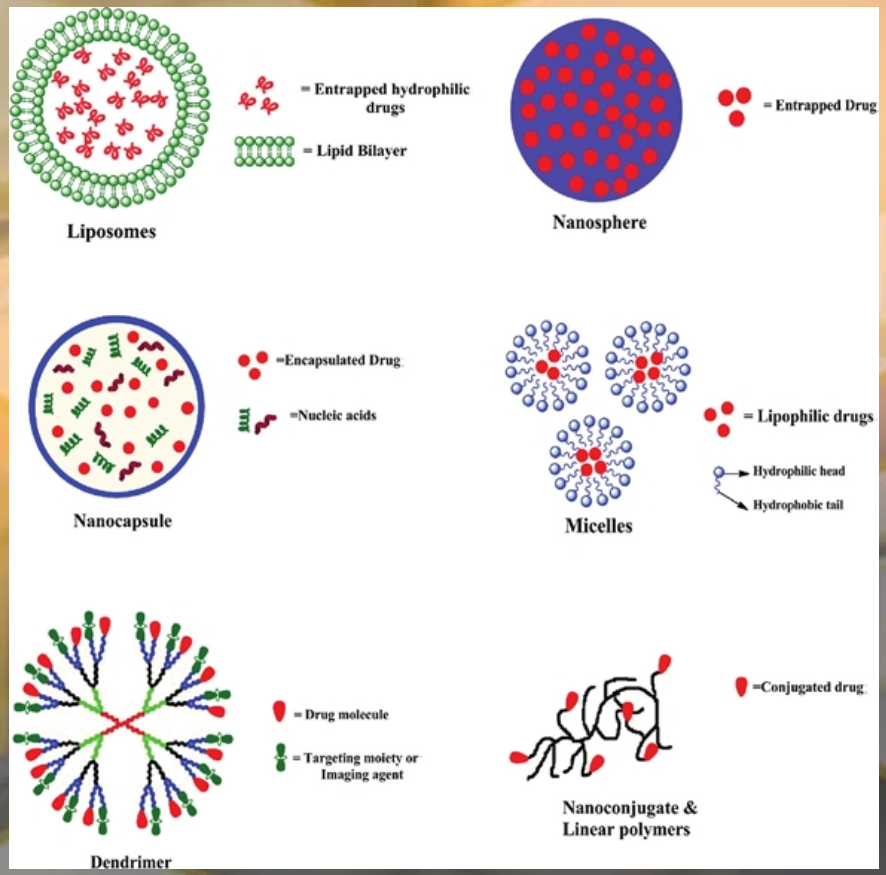
Time for questions

Credit: Shutterstock

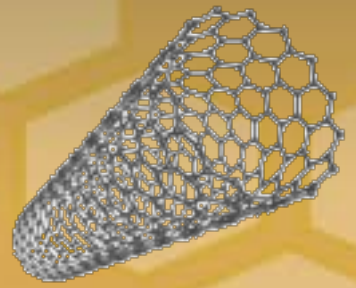
Drug delivery sistems

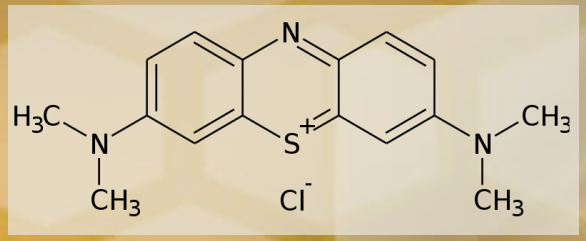




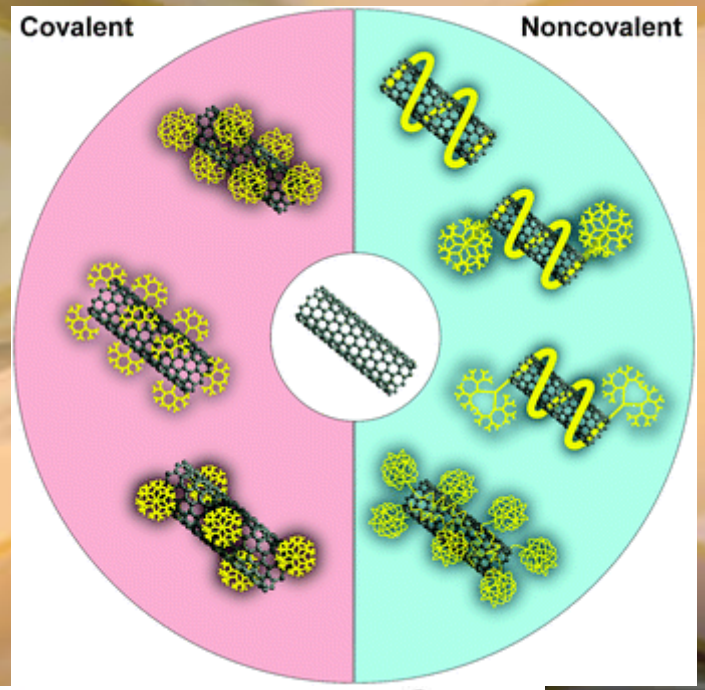


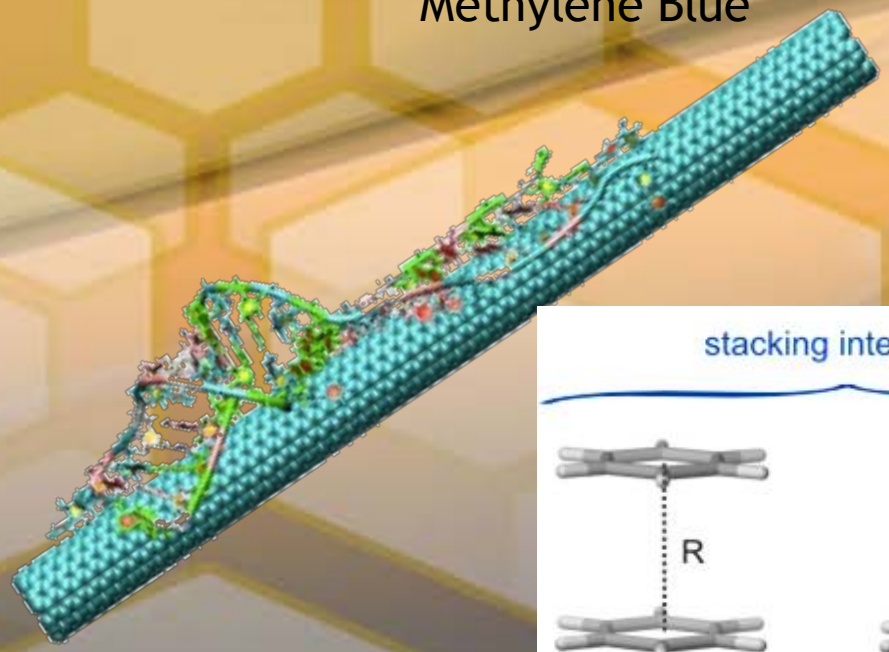
*In lab



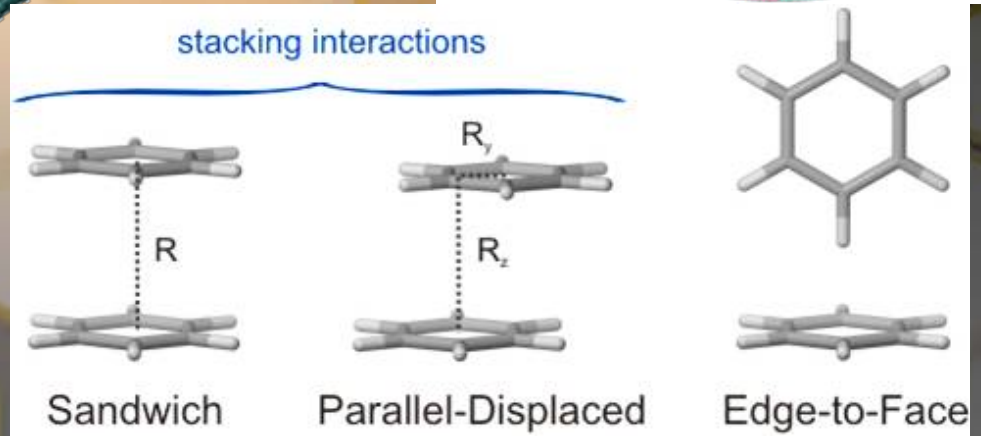


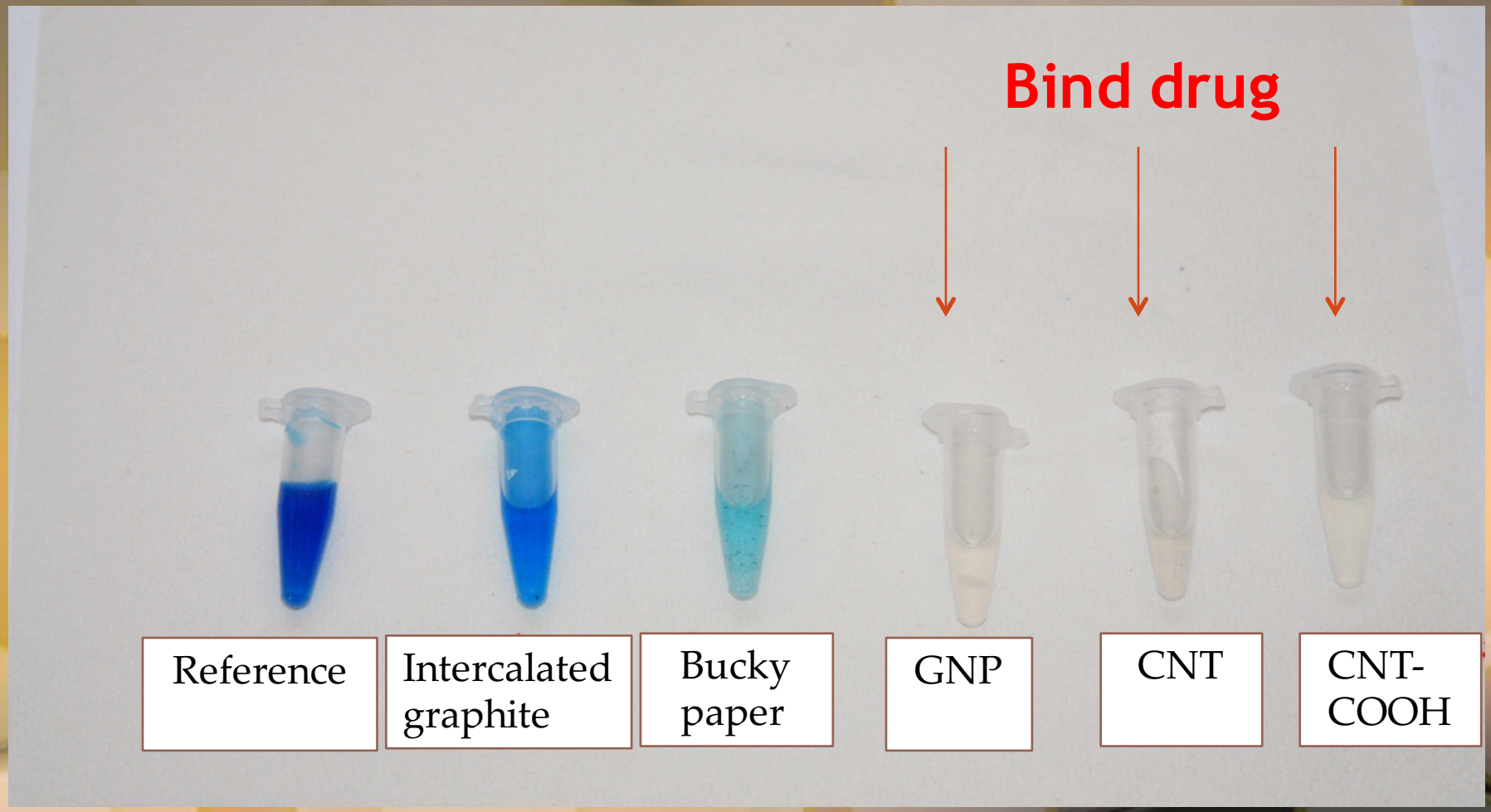
Methylene Blue





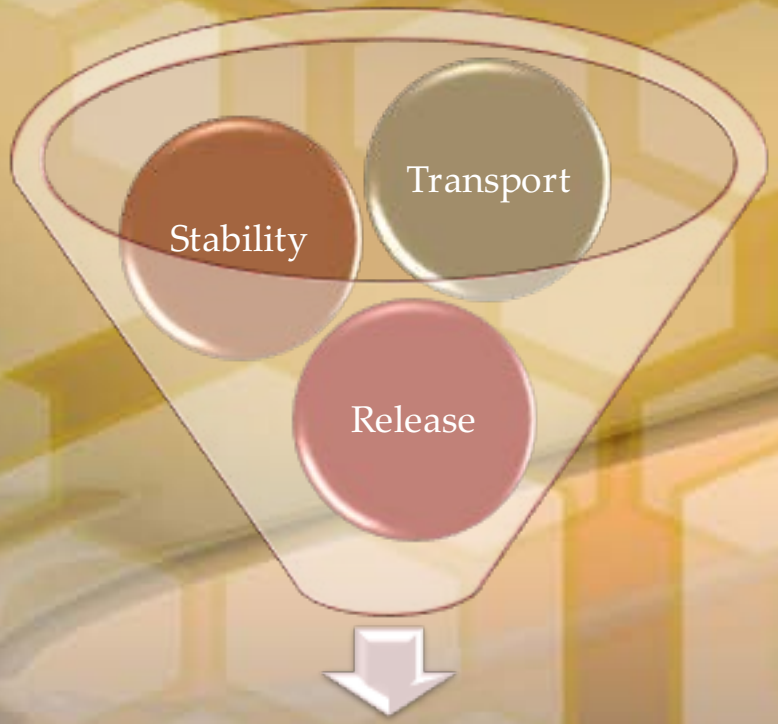
video





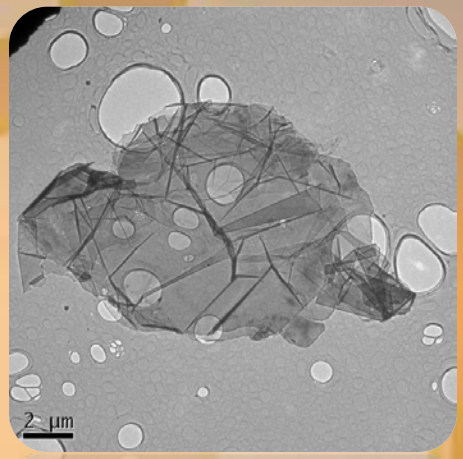
*Drug Delivery

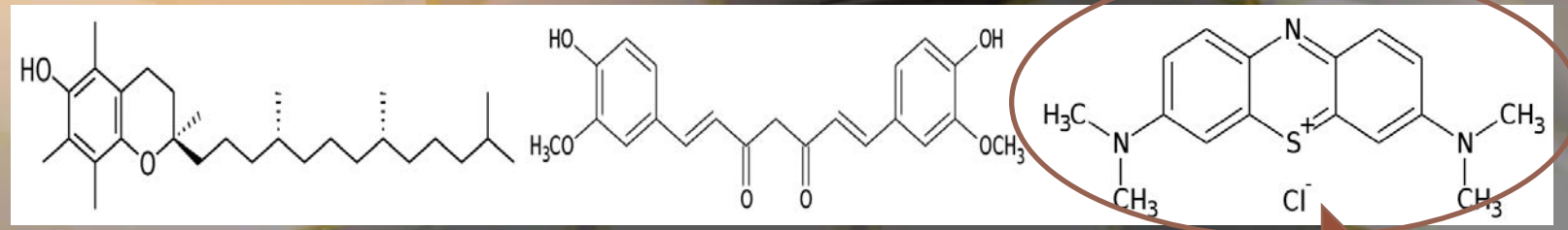
Drug delivery based on GNP



Drug delivery system

- Transport: mediated and improved by GNP
- Stability: obtained by surfactants
- Release: mediated by T and pH





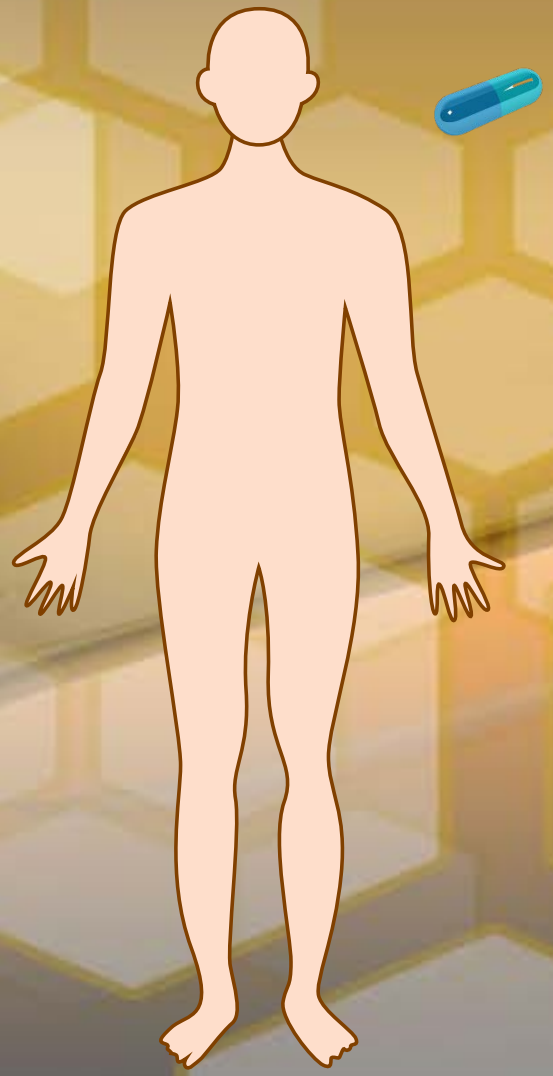
Solubility

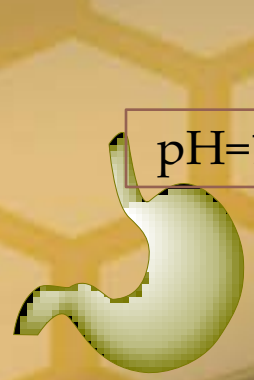
GNP stabilization

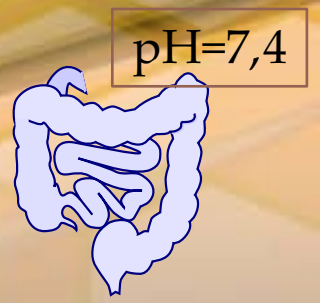
Stabilizer	Type	Rapporti testati
CTAB	Cationic surfactant	10:1 20:1 40:1 Than GNP
SDBS	Anionic surfactant	
Arabic Gum	Natural Polysaccharide	
PVP	Hydrophilic Polymer	
PVA	Hydrophilic Polymer	

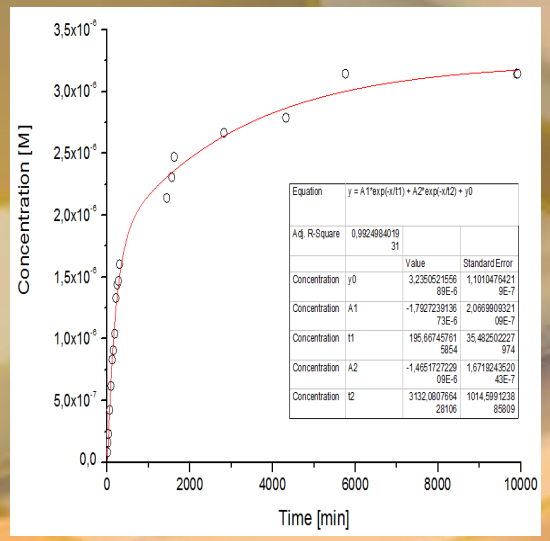
- CTAB, SDBS e PVP not stable
- PVA stable up to 15 days
- AG stable up to 50 days

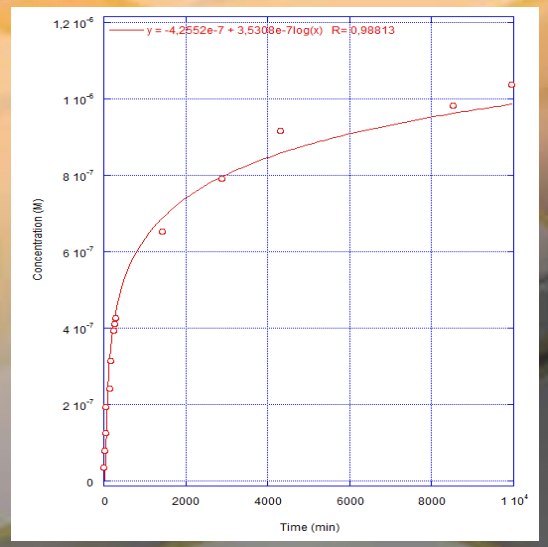
Kinetic of release





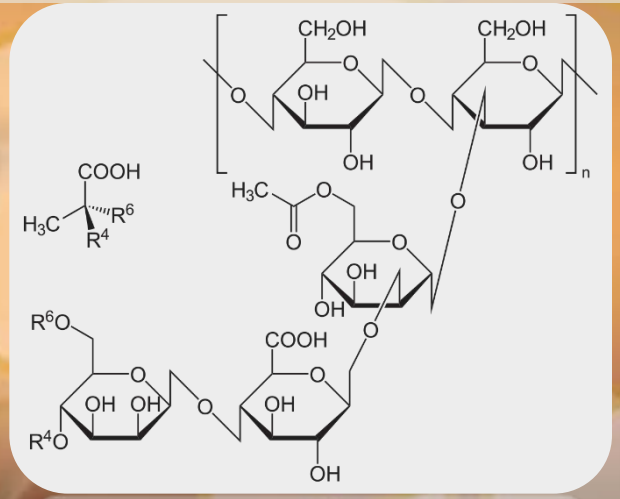






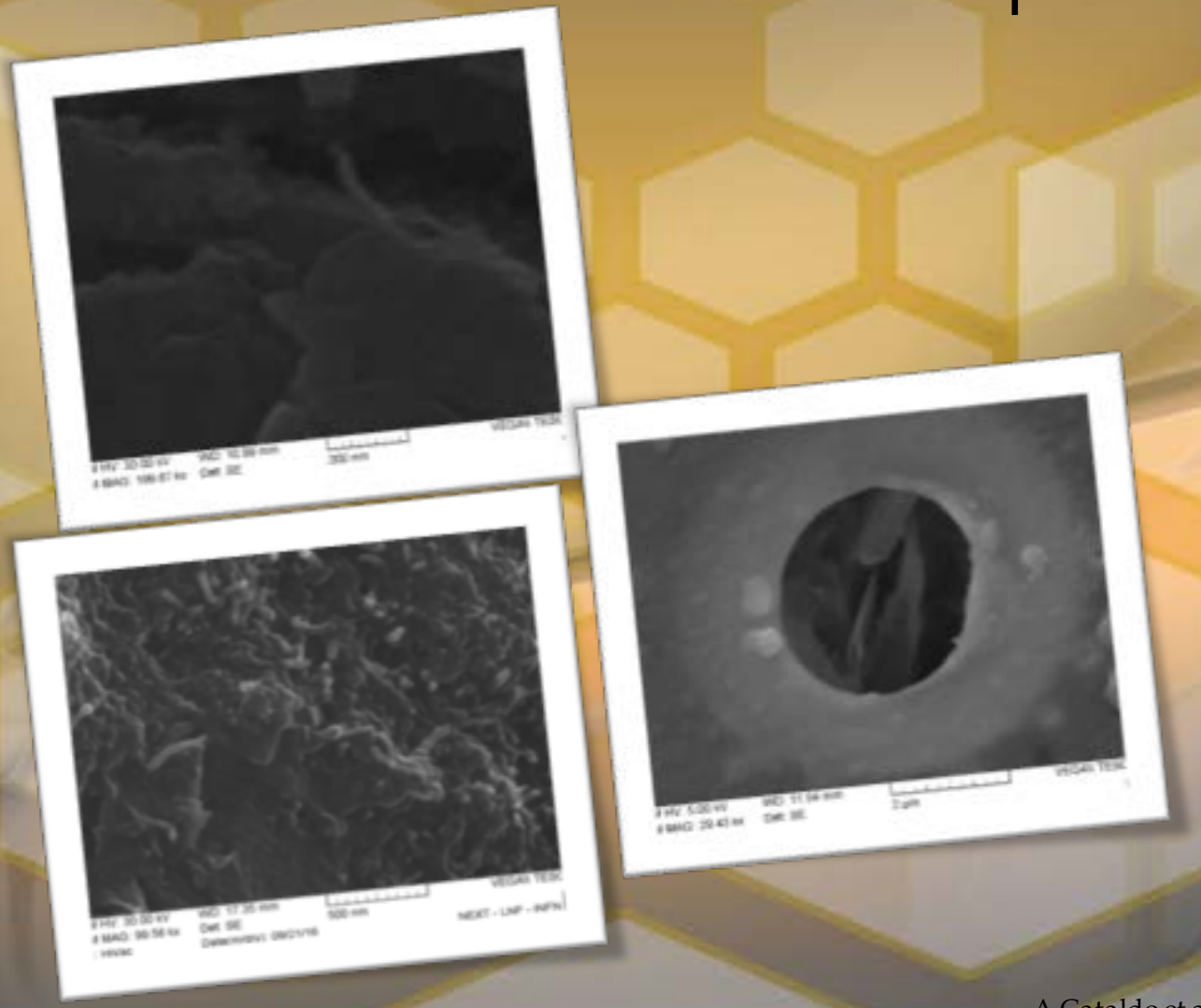
pH> 2.2

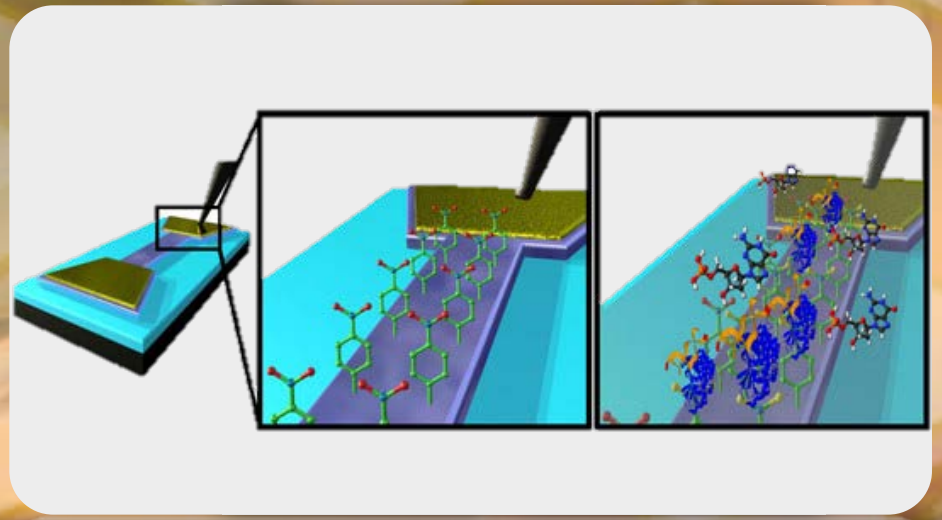
Negative charge due to deprotonation

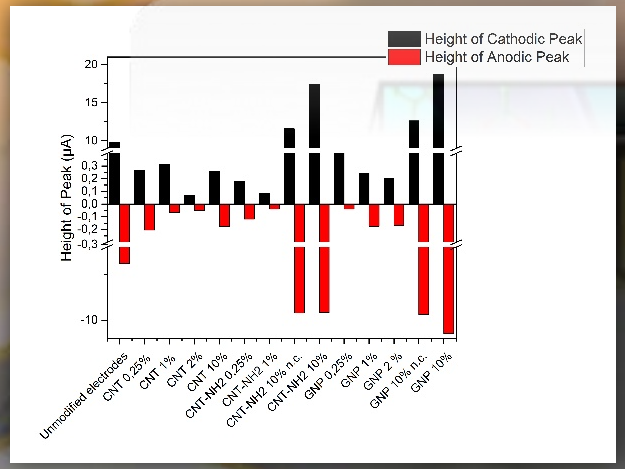


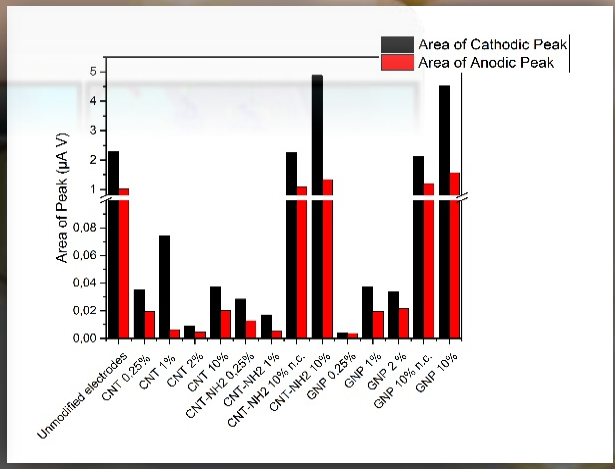
- Effective release at acidic pH
- Perspective: treatment of ulcerous infection

Modified Screen printed electrodes

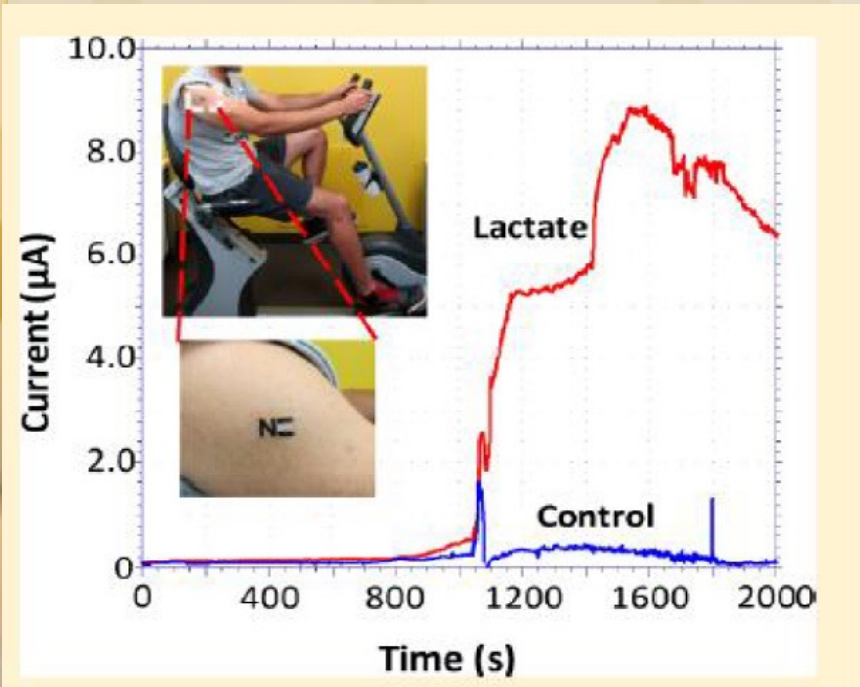


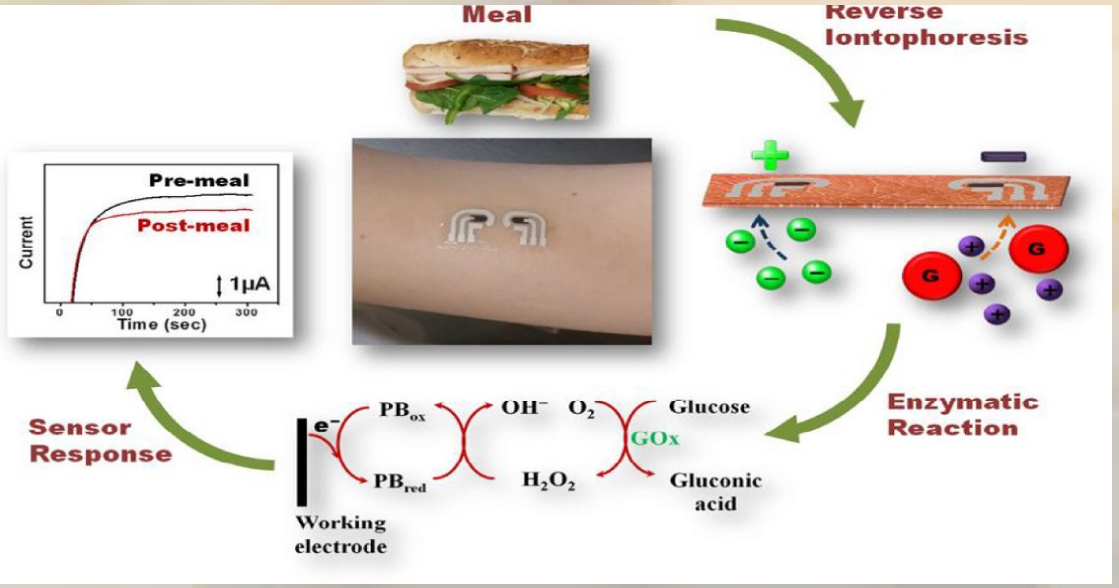






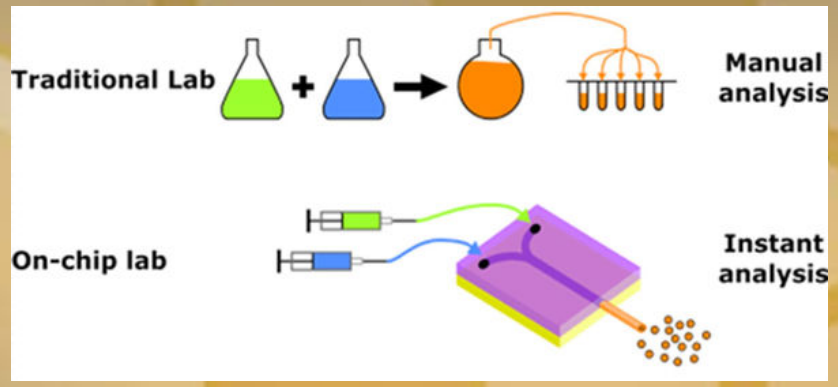
A Cataldo et al submitted

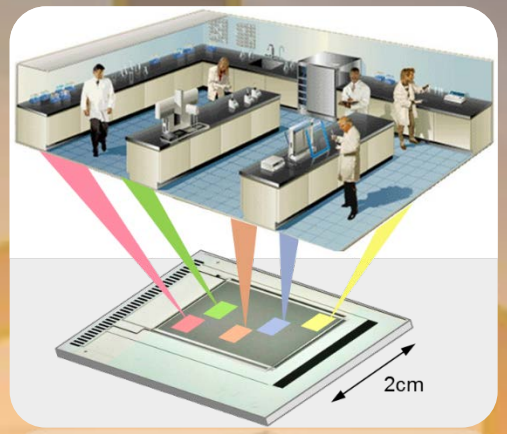


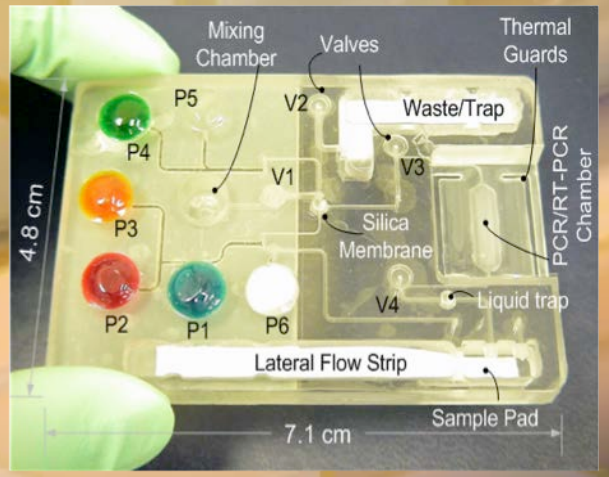


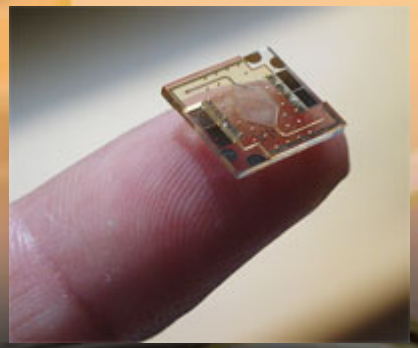
Arduini, Fabiana, et al. "Electrochemical biosensors based on nanomodified screen-printed electrodes: Recent applications in clinical analysis." *TrAC Trends in Analytical Chemistry* 79 (2016): 114-126.

Lab on chip

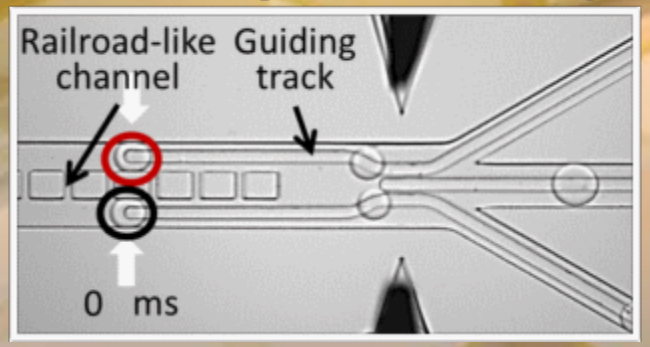




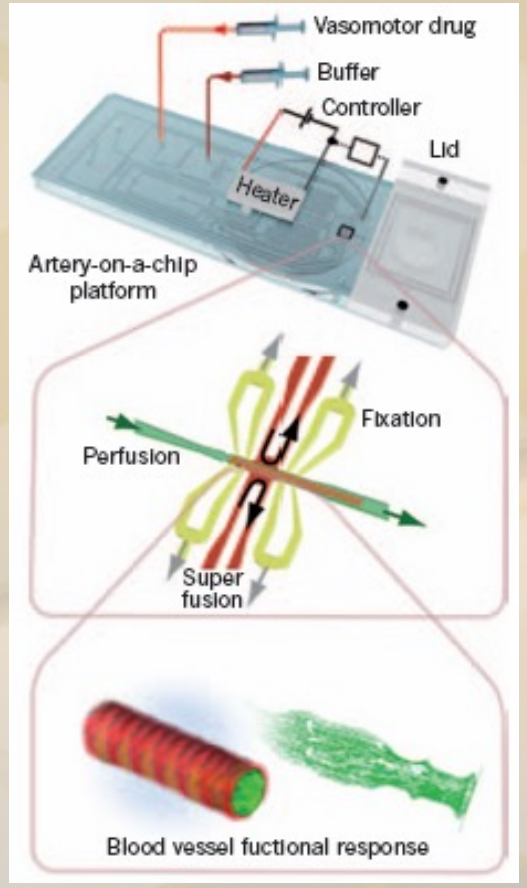


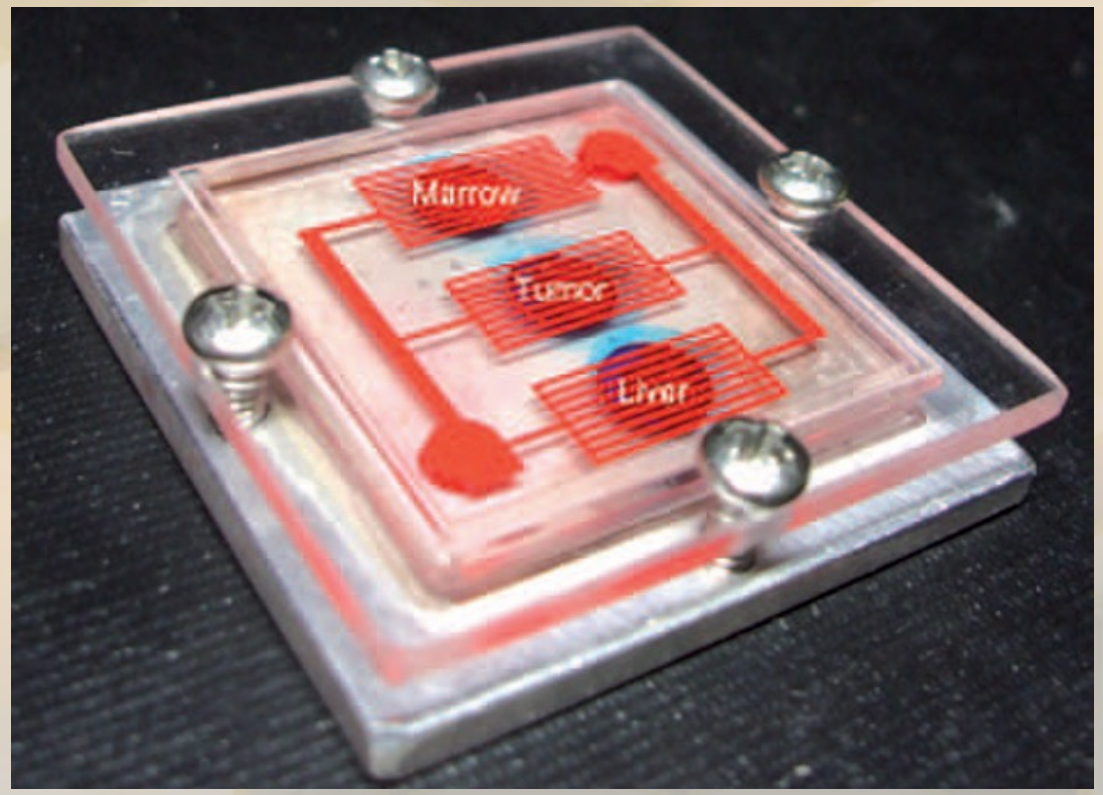


Fusion and sorting of two trains of droplets



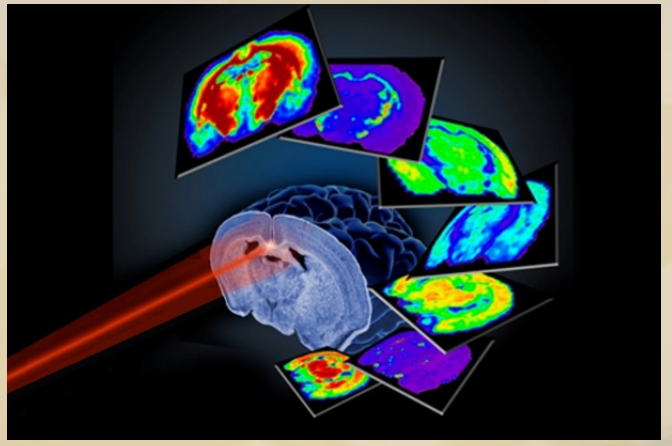
Lab on chip

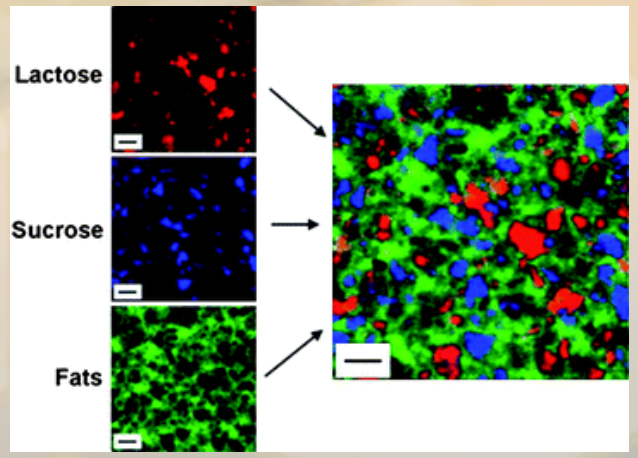


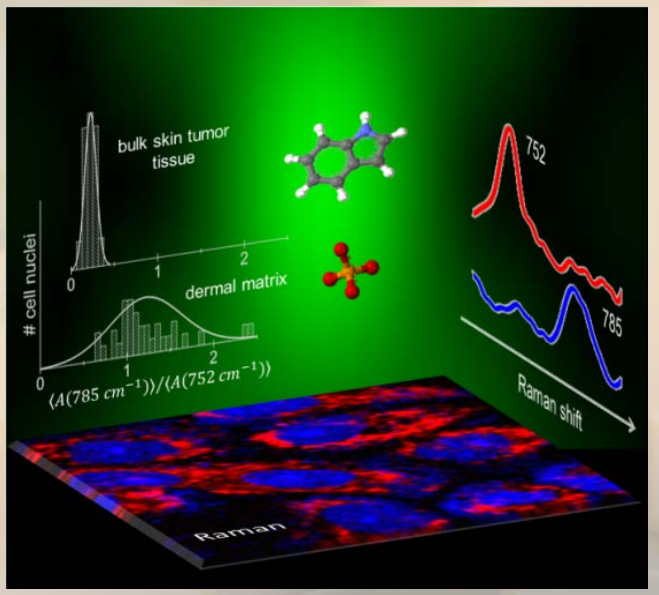


Baker, Monya. "A living system on a chip." *Nature* 471.7340 (2011): 661-665.

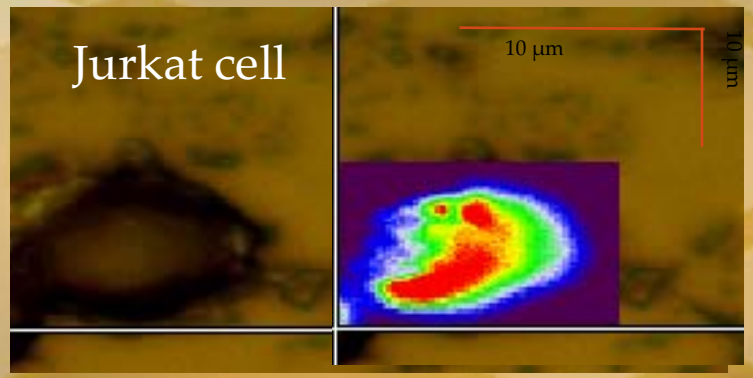
Imaging diagnostics

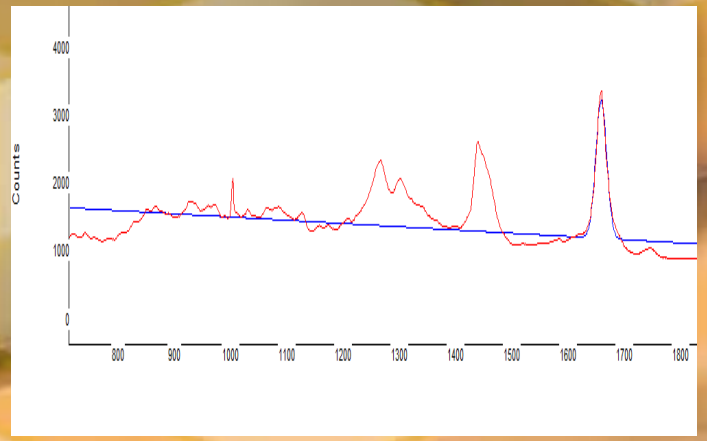






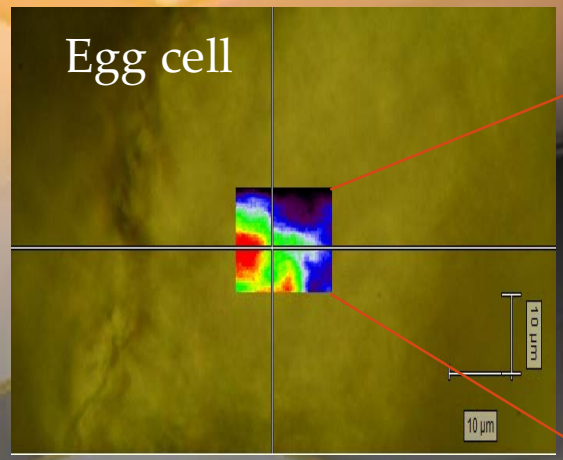
Raman imaging

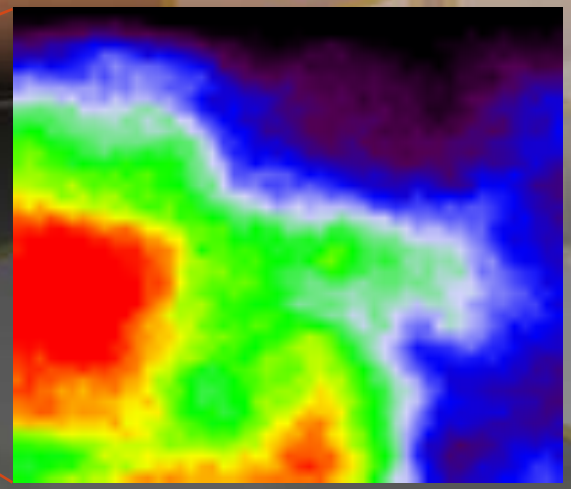


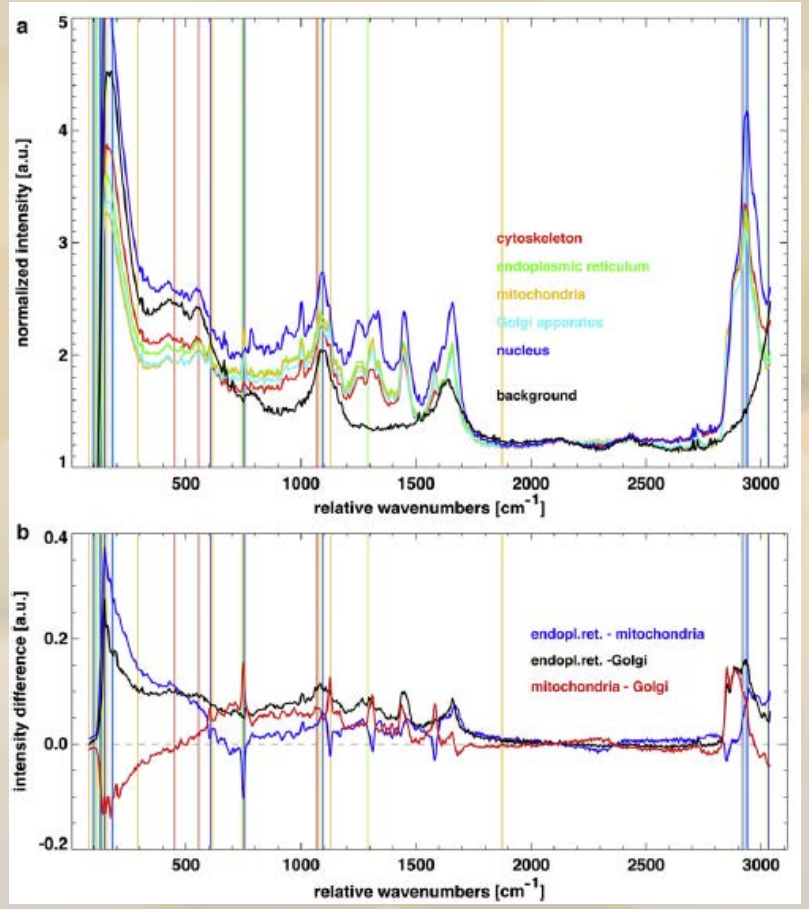


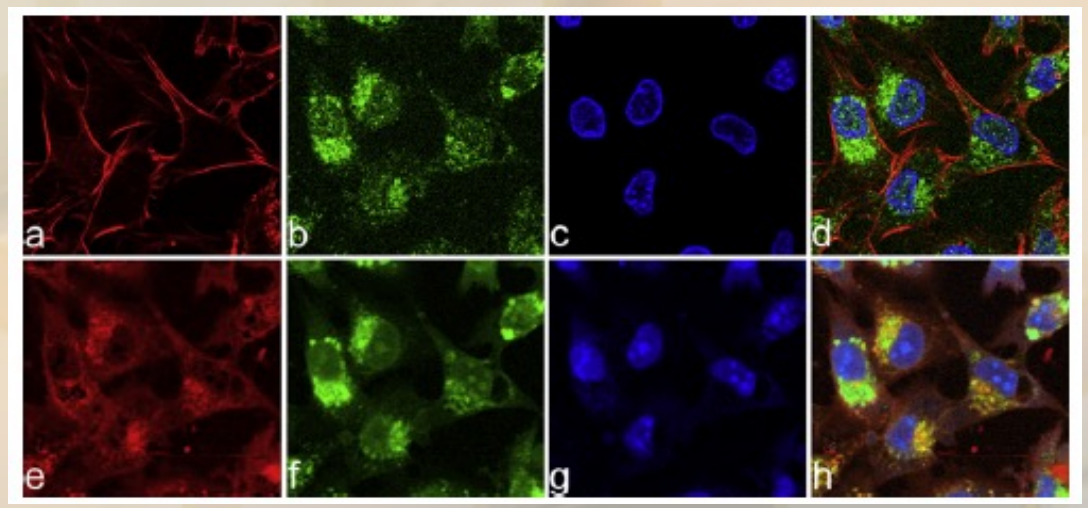
- Fluorescence
- Low Raman signal
- Thermolabile organic sample

- Reconstruction from spectroscopic data for identifying anomaly/mutations
- Identification of np/drug presents in cytosol

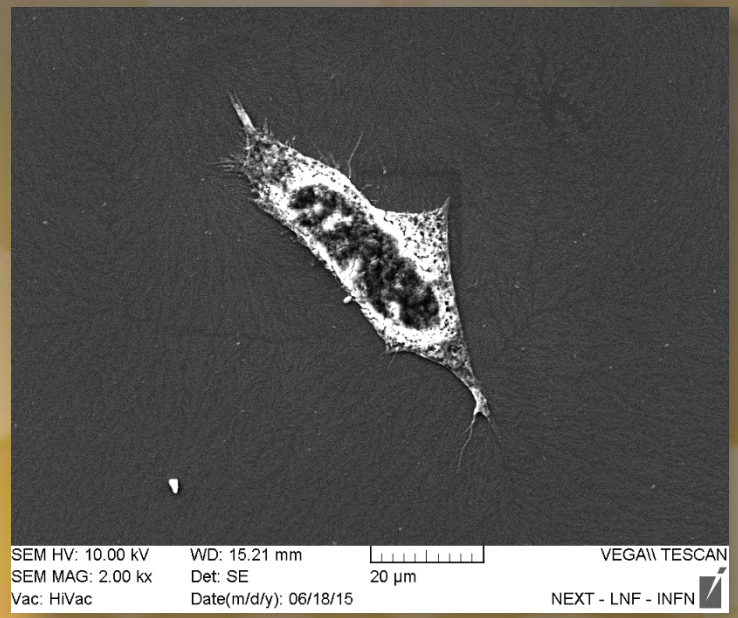


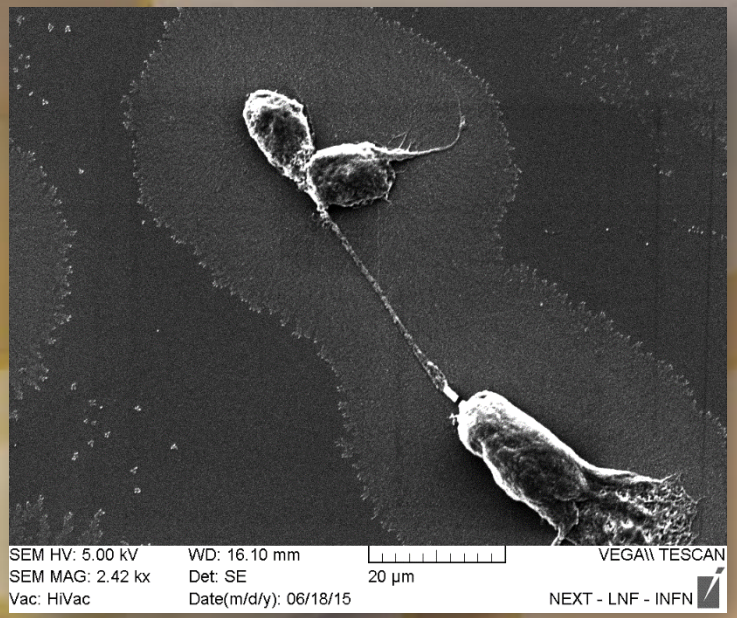


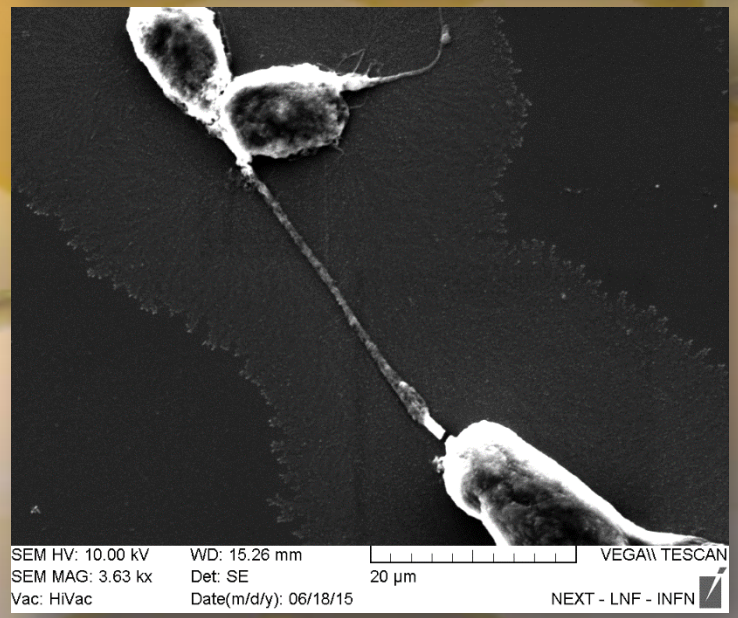


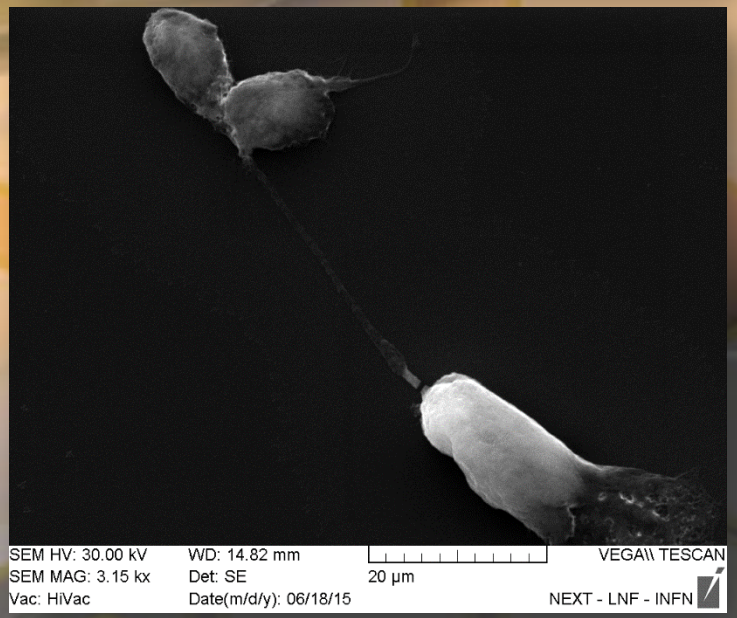


Klein, Katharina, et al. "Label-free live-cell imaging with confocal Raman microscopy." *Biophysical journal* 102.2 (2012): 360-368.



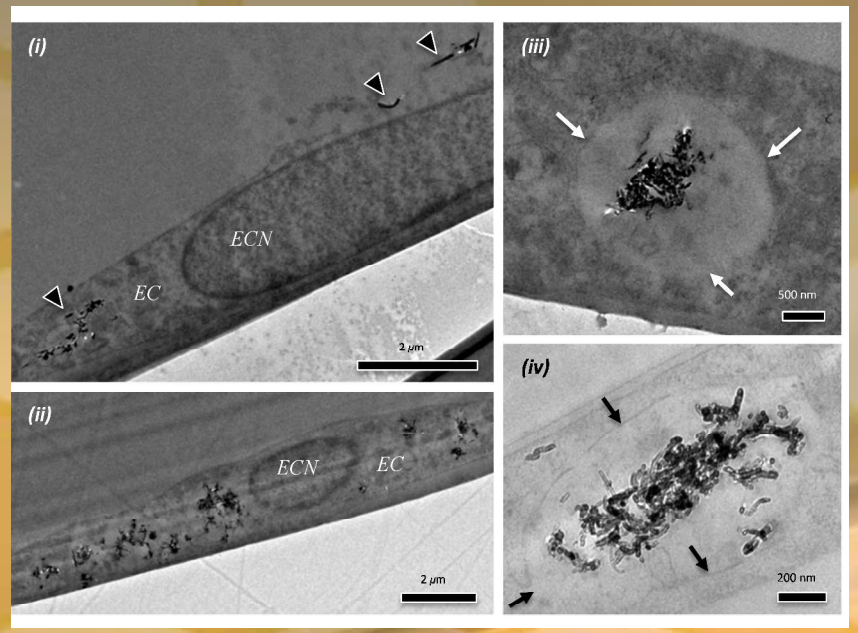


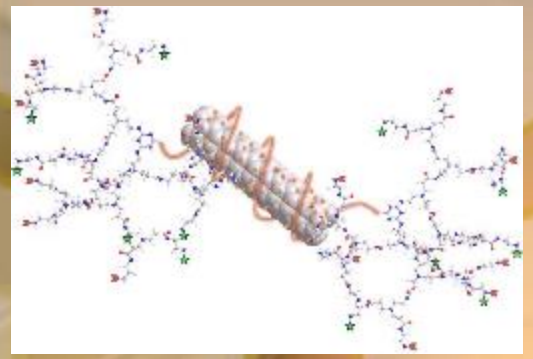


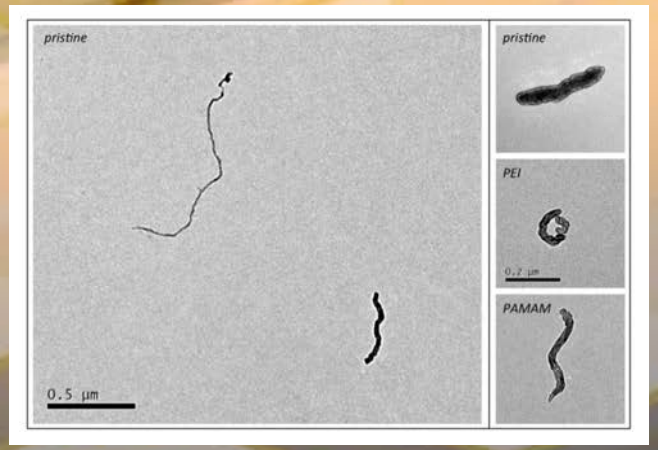


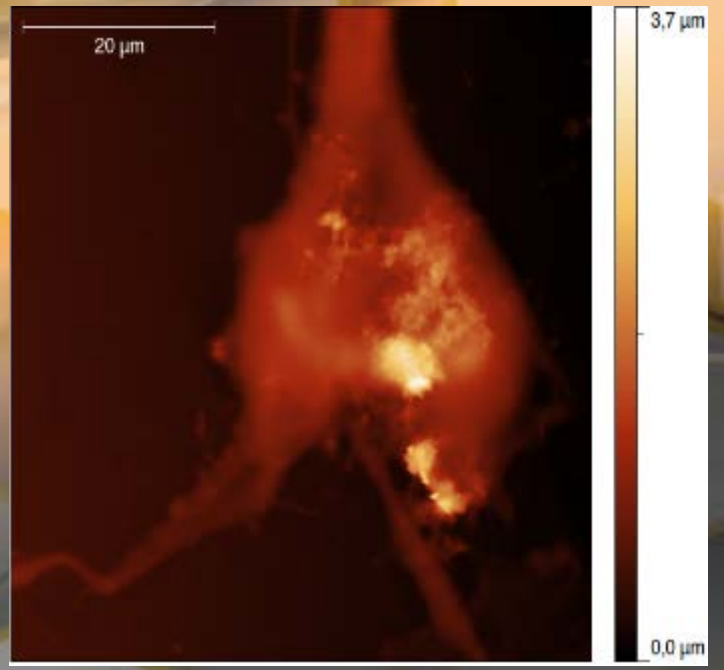
La microscopia alla biologia

Toxicology & Farmacology



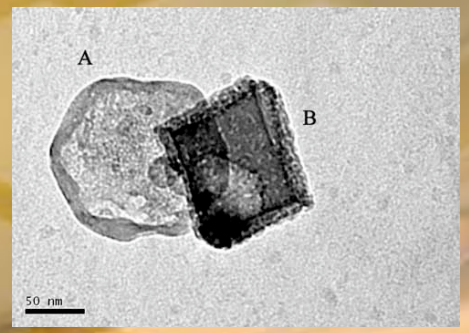




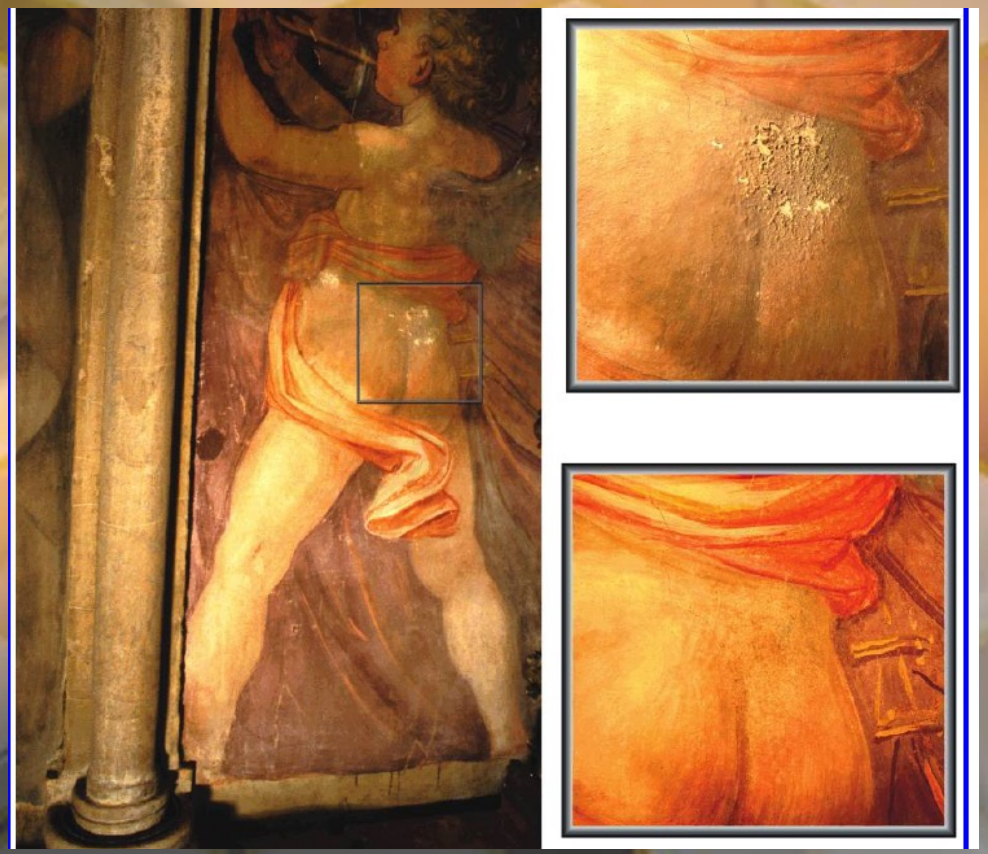


Nanotechnology in cultural heritage

$Ca(OH)_2$ hexagonal shape (A),
$CaCO_3$ prismatic shape (B)



Beato Angelico's Fresco in San Marco Abbey Florence



Gli Angeli Musicanti ,Santa Maria del Fiore Cathedral Florence.

Ambrosi, M., Dei, L., Giorgi, R., Neto, C., & Baglioni, P. (2001). Colloidal particles of Ca (OH) 2: properties and applications to restoration of frescoes. *Langmuir*, *17*(14), 4251-4255.

The case of Vasa war ship

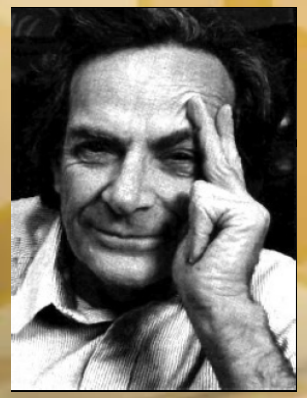
- The ship foundered after sailing about 1,300 m (1,400 yd) into her maiden voyage on 10 August 1628
- Carbonization due to the wood acidification (H_2SO_4)
- Solution?
  - Using of NP $Ca(OH)_2$ and $Mg(OH)_2$ to increase pH

Chelazzi, D., Giorgi, R., & Baglioni, P. (2006, April). Nanotechnology for Vasa Wood De-Acidification. In Macromolecular symposia (Vol. 238, No. 1, pp. 30-36). Weinheim: WILEY-VCH Verlag.

https://commons.wikimedia.org/wiki/File:The_Vasa_from_the_Bow.jpg

Thanks for your electronic attention

Richard Feynman
“There’s Plenty of Room at the Bottom”



Nanotechnology is an idea that most people simply didn't believe.
Ralph Merkle
https://www.brainyquote.com/topics/nanotechnology-quotes