Plasmonic nanostructures employed for optical and colorimetric (bio)sensing strategies

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Is this Nano?

Nanotechnology is a "*system of innovative methods to control and manipulate matter at near-atomic scale to produce new materials, structures, and devices*".

Nanomaterials (NMs)

Materials in the range of 100 nm are considered to be nanoparticles. They exhibit a wide range of properties, including optical, electrical, catalytic, magnetic, and biological activity.

Regulatory Toxicology and Pharmacology 65 (2013) 119–125

Contents lists available at SciVerse ScienceDirect

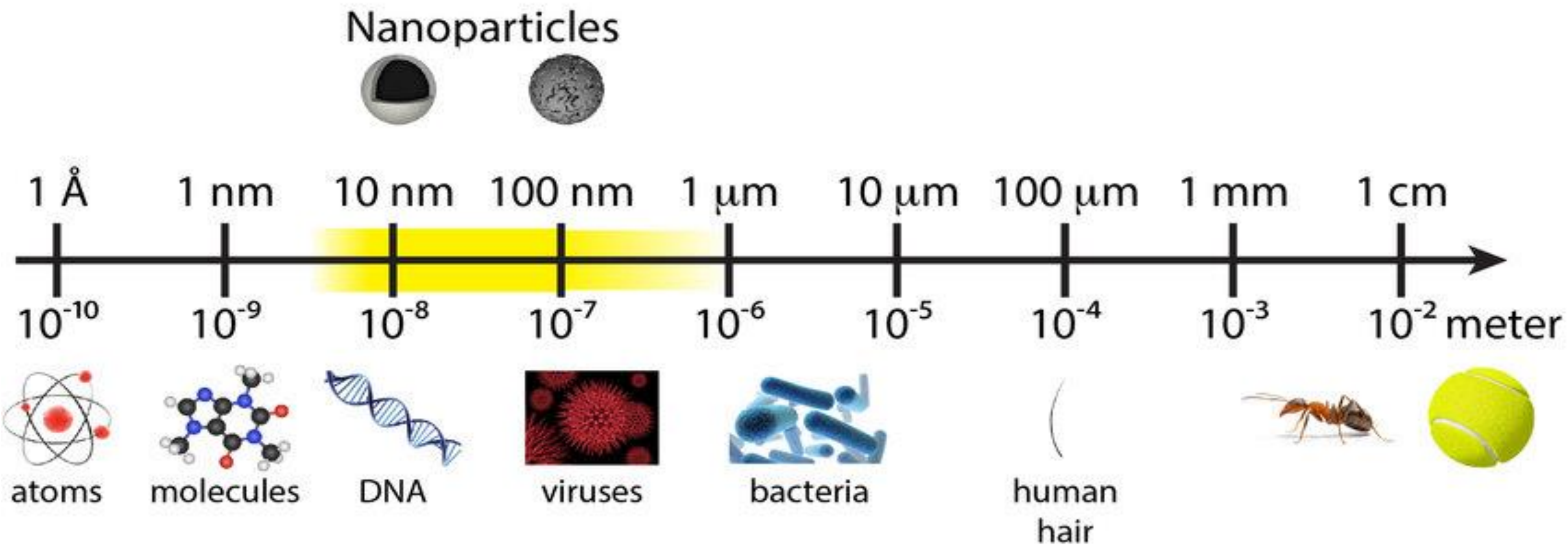
Regulatory Toxicology and Pharmacology

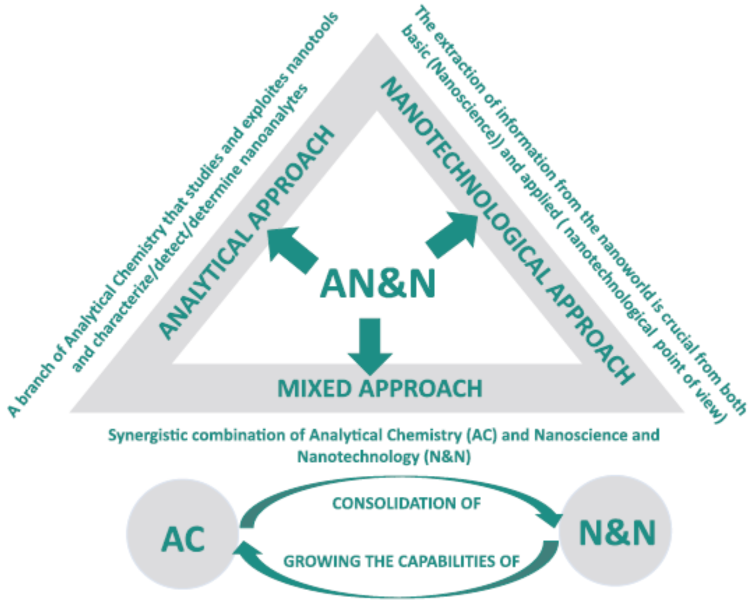
journal homepage: www.elsevier.com/locate/yrtph

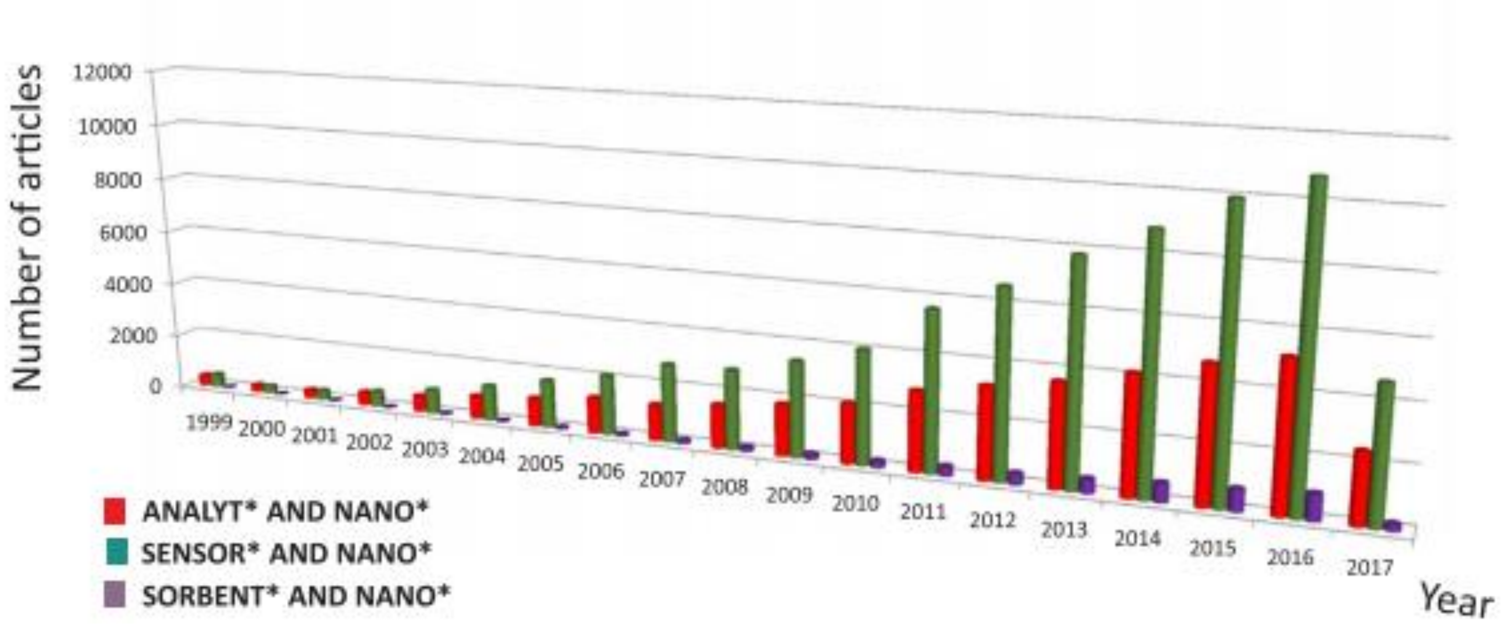
Considerations on the EU definition of a nanomaterial: Science to support policy making

Eric A.J. Bleeker *, Wim H. de Jong, Robert E. Geertsma, Monique Groenewold, Evelyn H.W. Heugens, Marjorie Koers-Jacquemijns, Dik van de Meent, Jan R. Popma, Anton G. Rietveld, Susan W.P. Wijnhoven, Flemming R. Cassee, Agnes G. Oomen

Is this Nano?





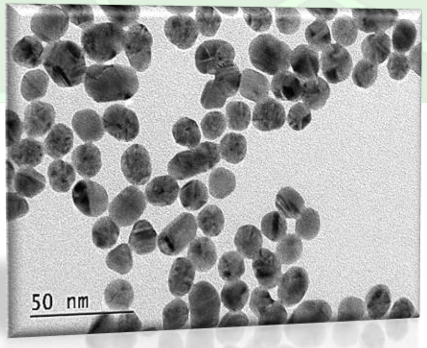


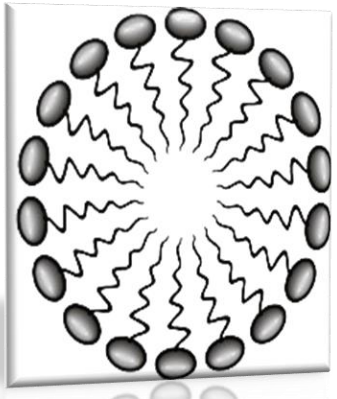
European Commission, Commission Recommendation of 18 October 2011 on the definition of nanomaterial, Official Journal of the European Union. 2011/696/EU: 38-40, 2011

Nanomaterials

Metal NPs

Nano-objects
Nano-particles

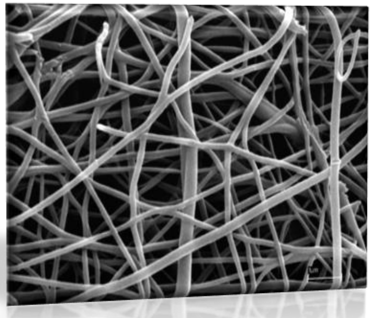




Micelle

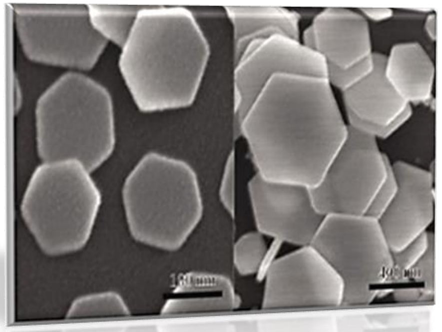
Nanomaterials (NMs)

Nanofiber

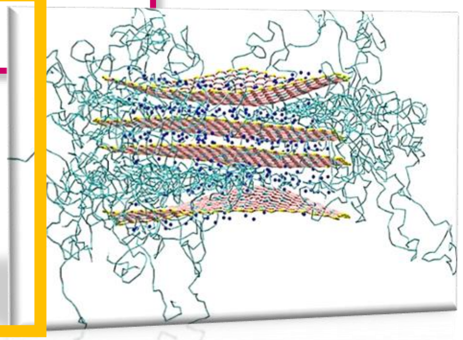


Nanoformulations

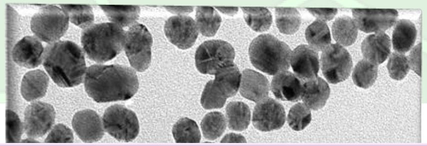
Nanoplate



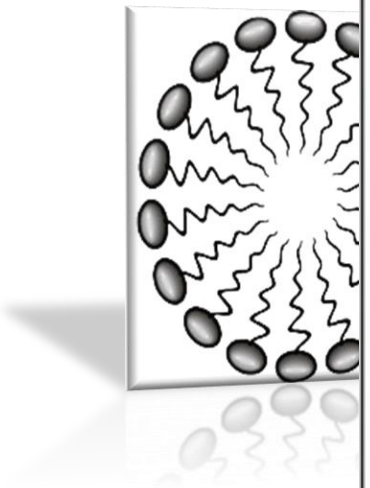
Nanocomposite

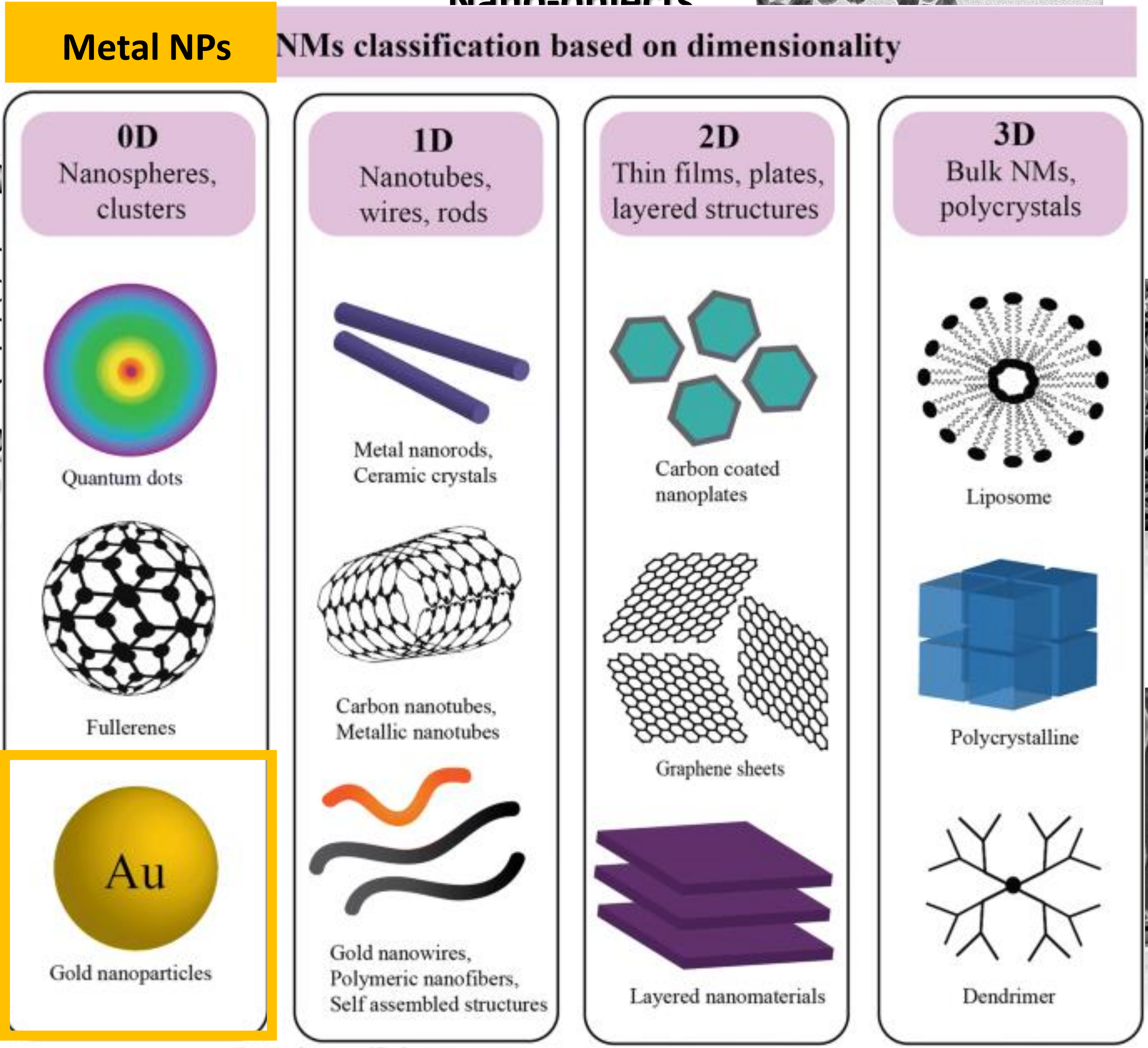


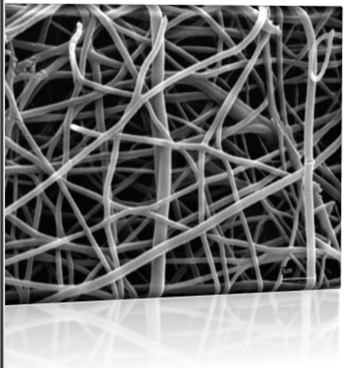
Nanomaterials

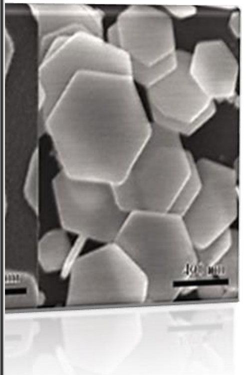


Nano-objects



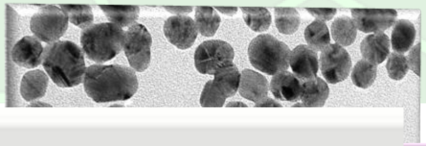


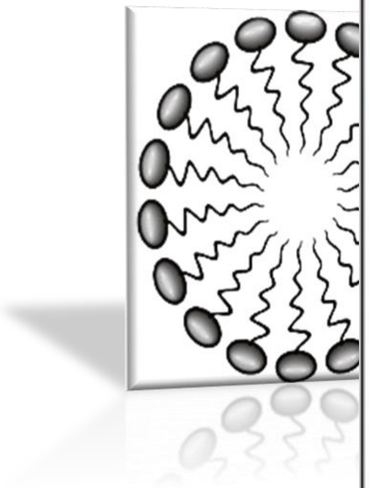


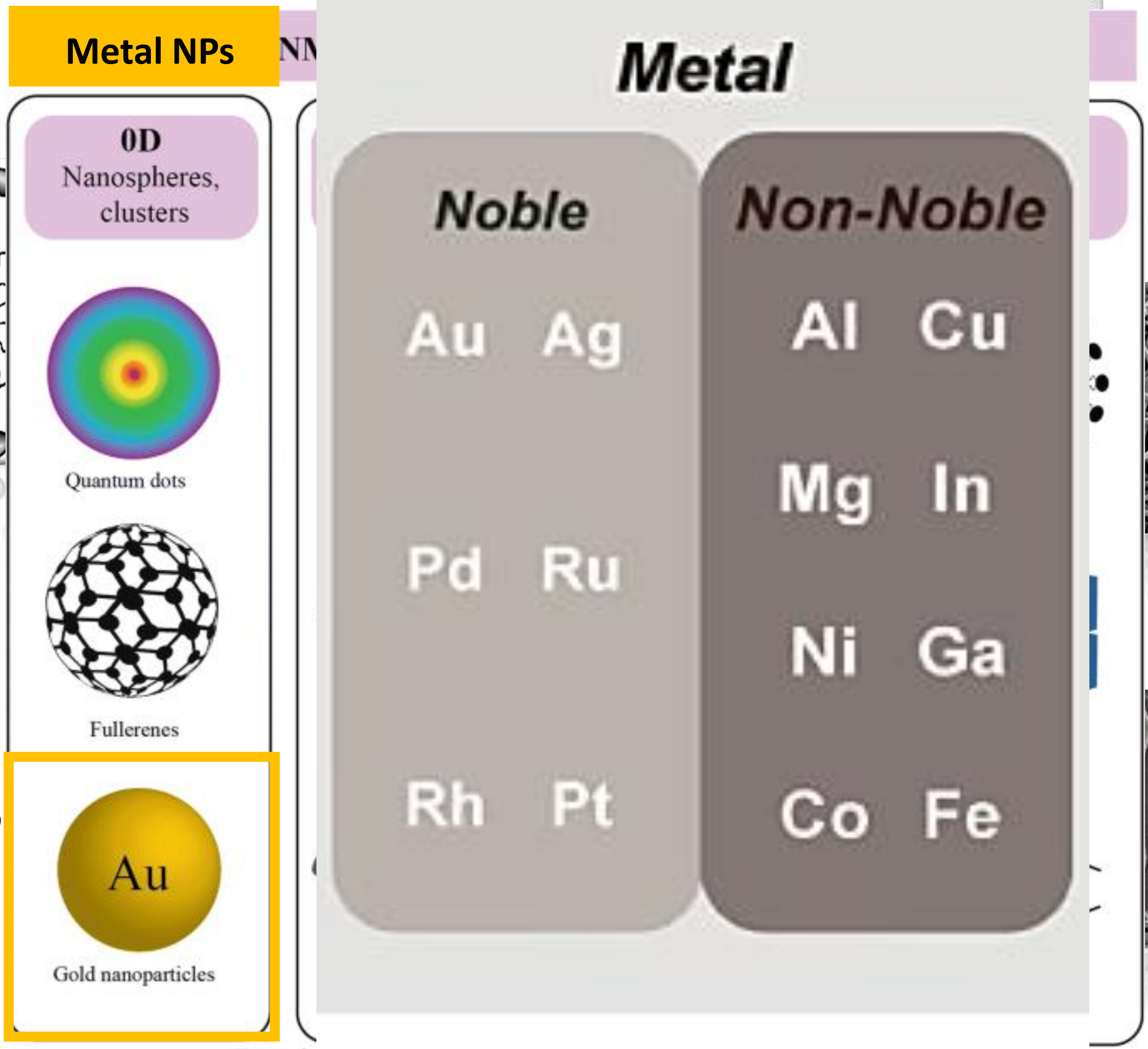


Nanocomp

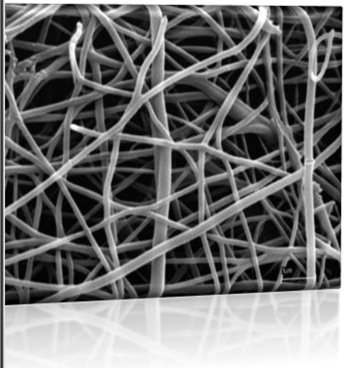
Nanomaterials

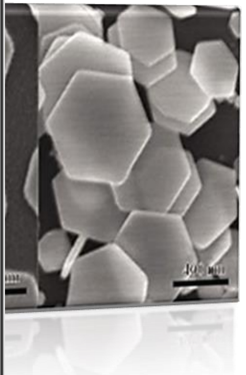




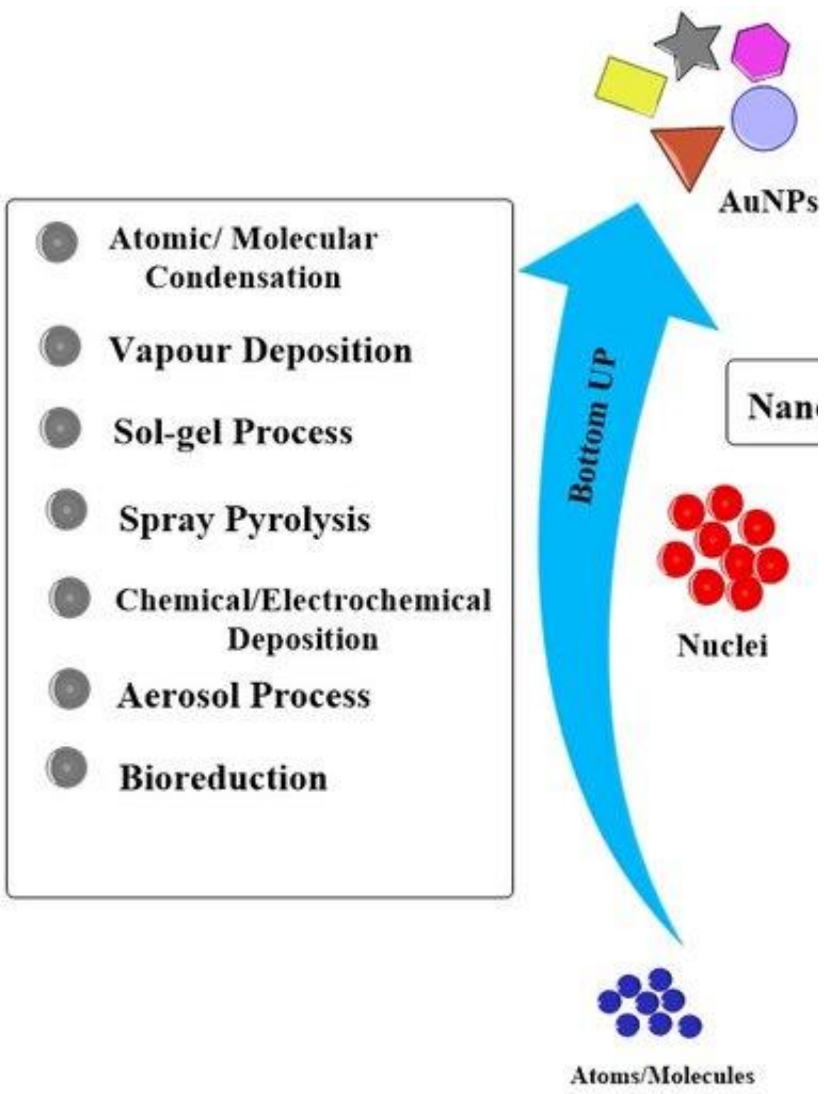


Nanocomp

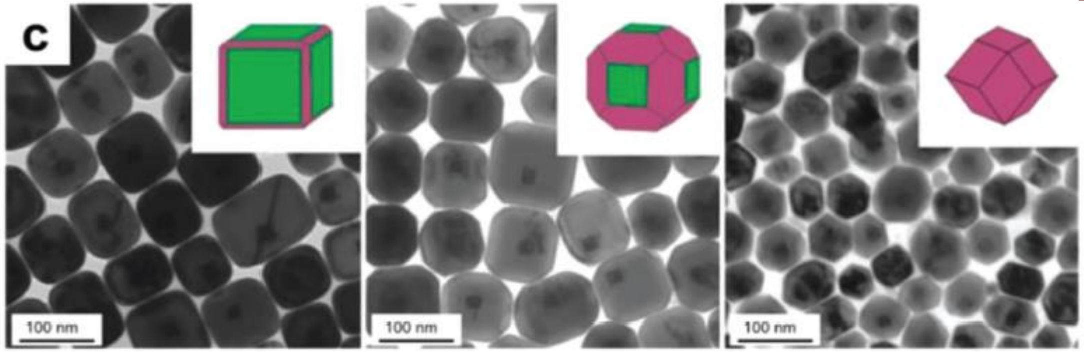




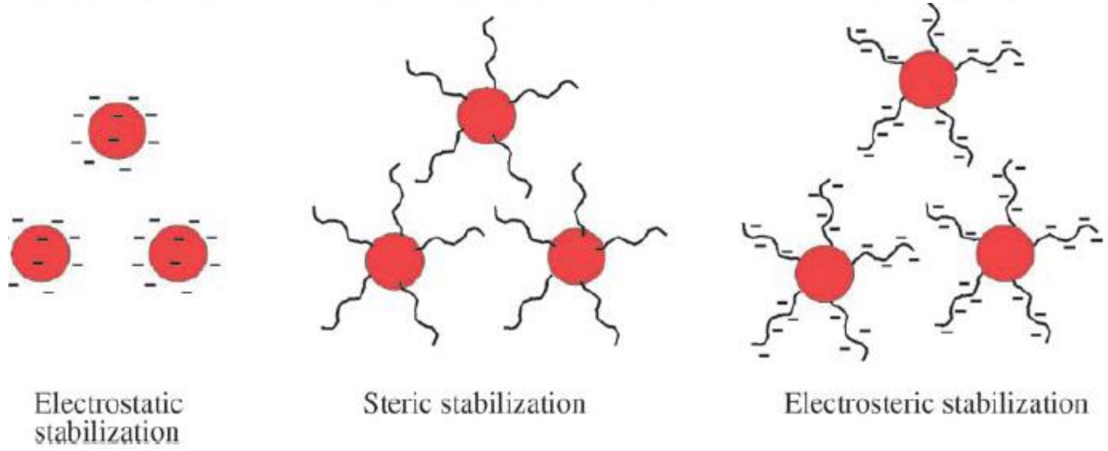
Metal based Nanoparticles



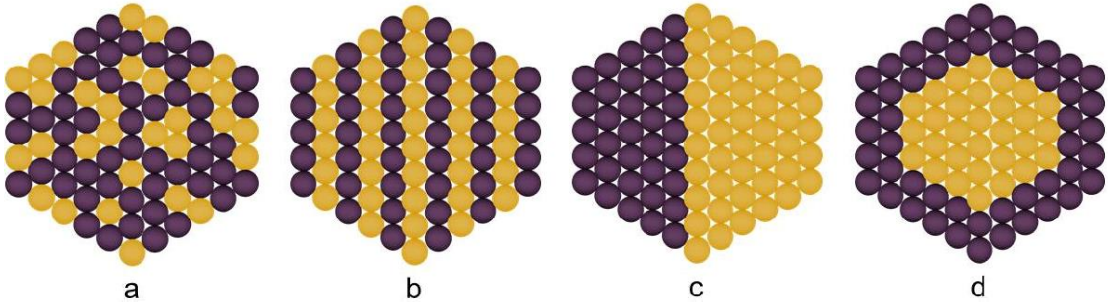
SHAPE



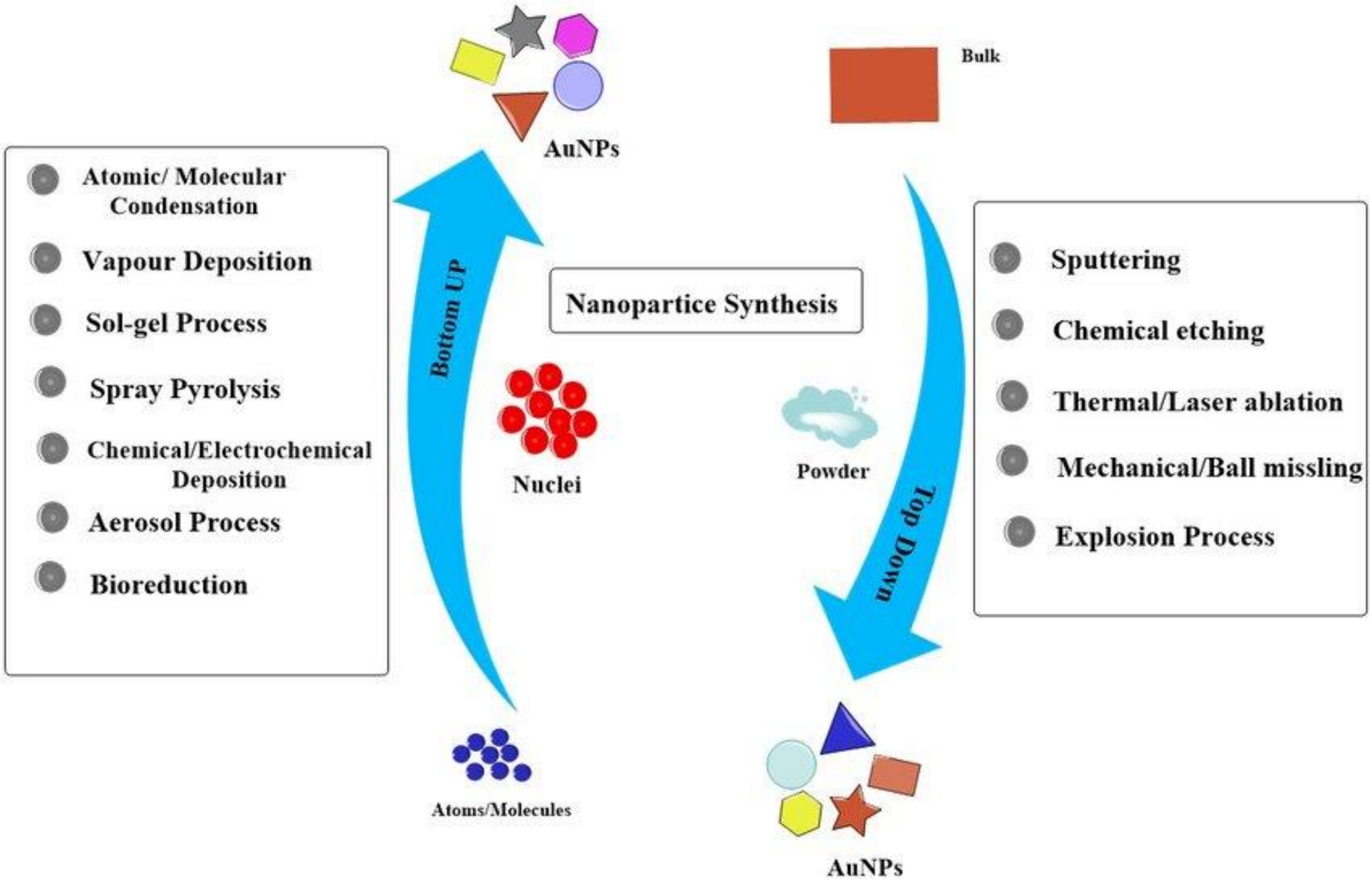
SURFACE



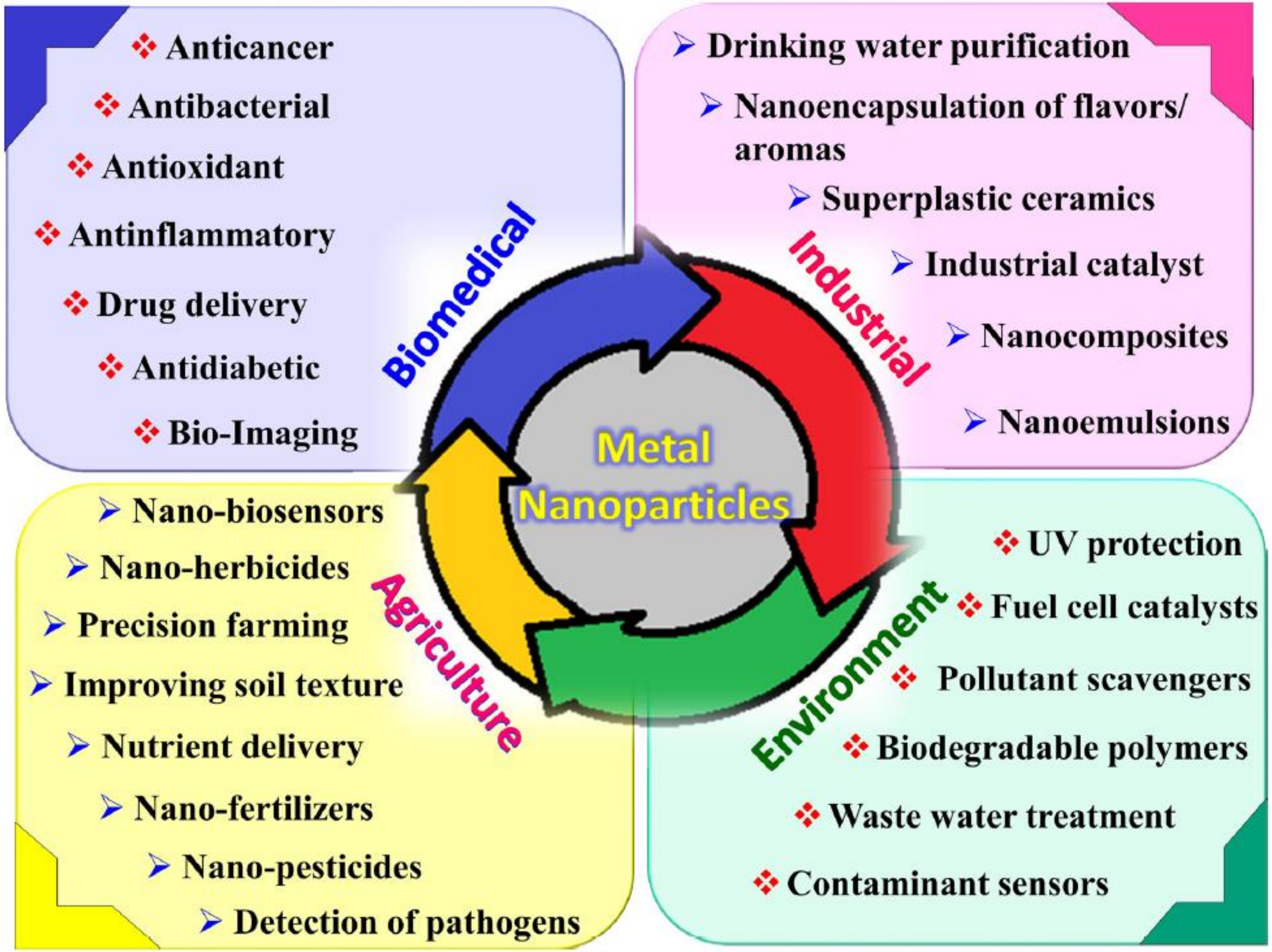
COMPOSITION



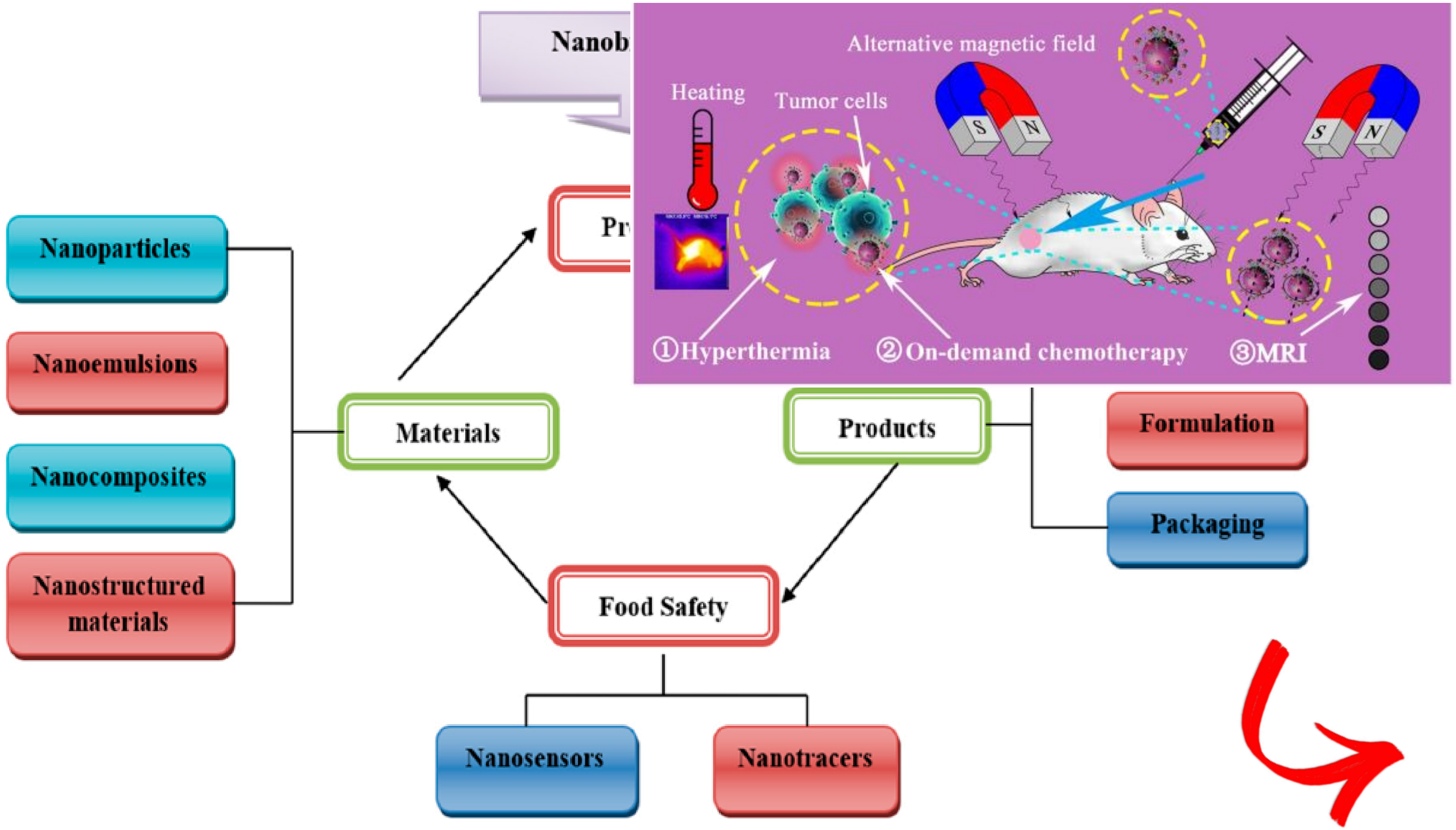
Metal based Nanoparticles

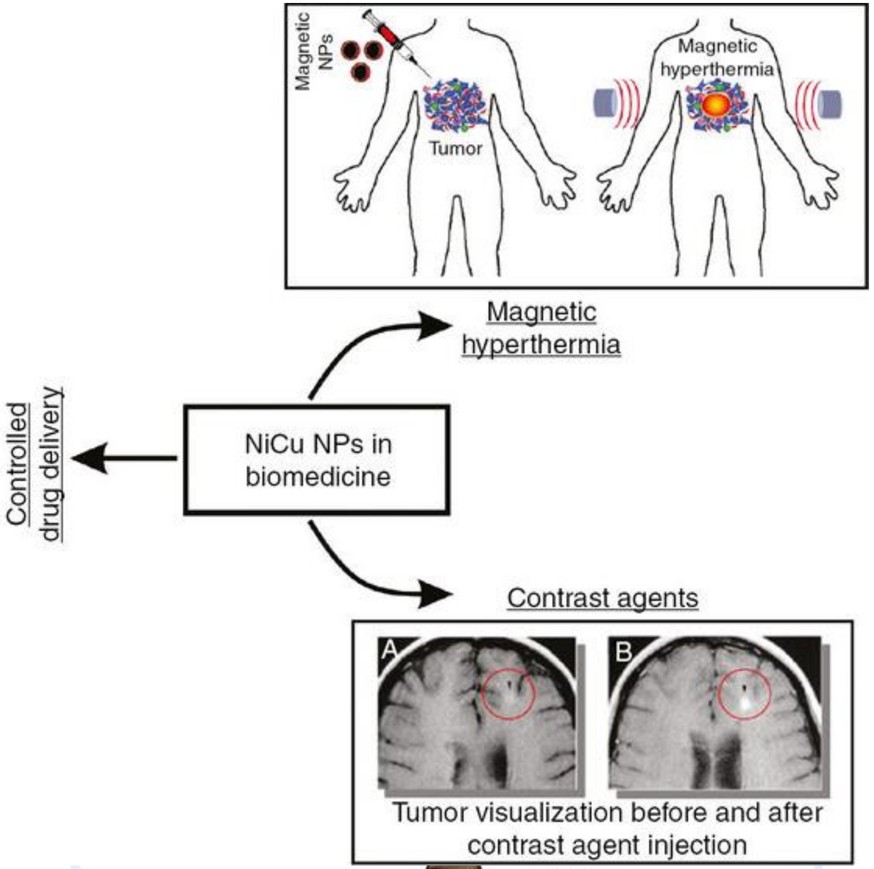


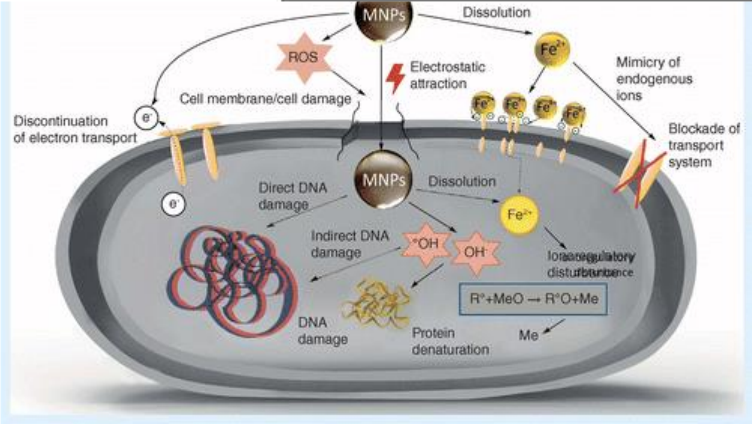
Metal Nanoparticles application fields



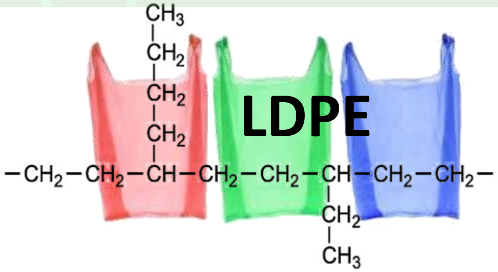
Nanotechnology







Nanoparticles application in food technology

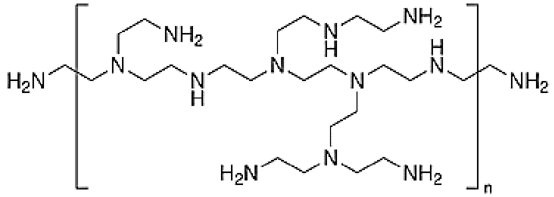


Commercial low-density polyethylene (LDPE) films coated using a layer-by-layer (LbL) technique by alternating the deposition of polyethyleneimine (PEI), poly(acrylic acid) polymer (PAA) solutions and antimicrobial silver nanoparticles (Ag).

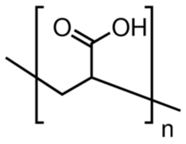
2 different LbL condition

Modified pH (MpH)

PEI pH 9
PAA pH 6.5



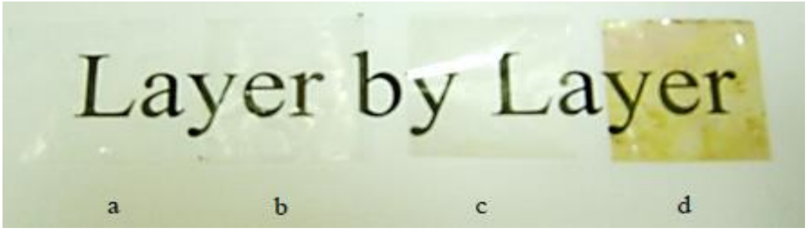
PEI



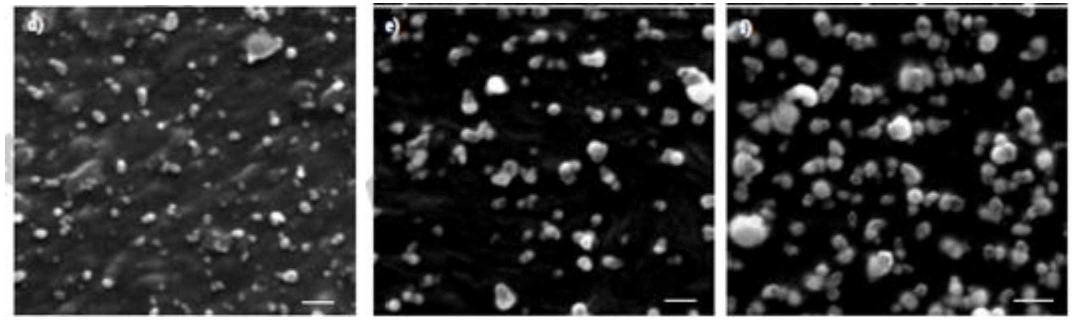
PAA

Non-Modified pH (NMpH)

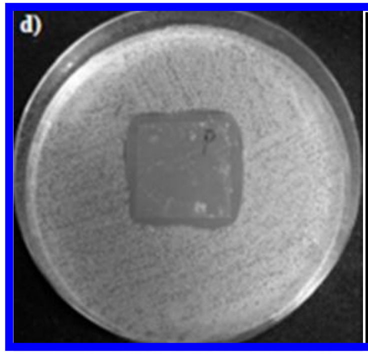
PEI pH 10.5
PAA pH 4



The colour changes of a) LDPE films and b) LDPE LbL coated (3 coatings) films without Ag and c) AgNPs presence on LDPE LbL coated (3 coatings) films immersed in 0,5% $AgNO_3$, or d) AgNPs presence on LDPE LbL coated with (3 coatings) film immersed in 5% $AgNO_3$ and UV/ozone treated for 20 min.

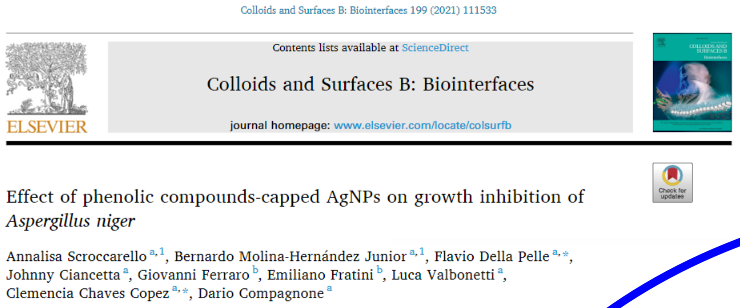


(d) LbL coated (3 coating) immersed in 0,5% $AgNO_3$, (e) LbL coated (3 coatings) immersed in 2% $AgNO_3$; and (f) LbL coated (3 coatings) immersed in 5% $AgNO_3$. Scale bar = 500nm



	Inibition zone (mm^2)	
Film	*S. aureus*	*P. fluorescens*
LPDE films	0.00	0.00
LPDE + PEI/PAA (MpH)	350.4 ± 13.30	694.8 ± 19.15
LPDE + PEI/PAA (NMpH)	460.0 ± 25.41	737.0 ± 15.08

MNPs as antimicrobial agent


Colloids and Surfaces B: Biointerfaces 199 (2021) 111533

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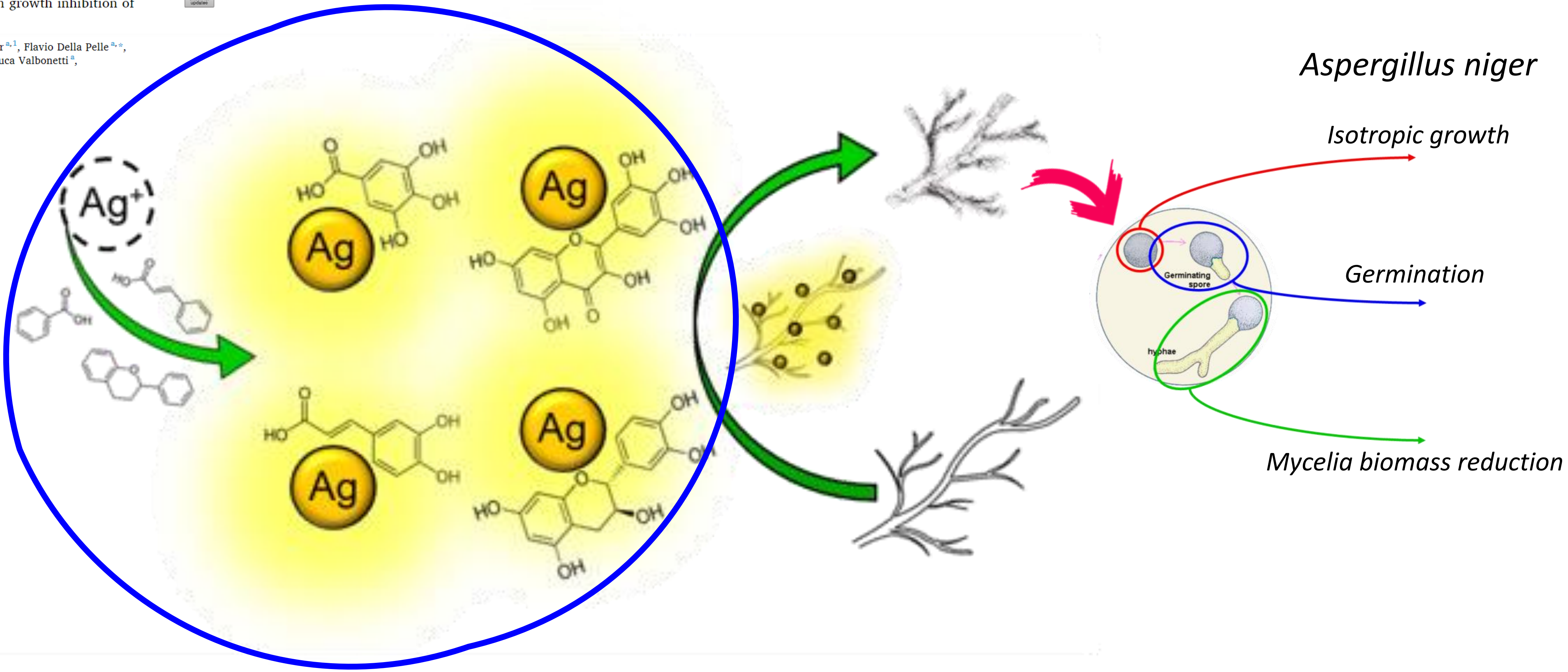
journal homepage: www.elsevier.com/locate/colsurfb

ELSEVIER

Effect of phenolic compounds-capped AgNPs on growth inhibition of *Aspergillus niger*

Annalisa Scroccarello[a,1], Bernardo Molina-Hernández Junior[a,1], Flavio Della Pelle[a,*], Johnny Ciancetta[a], Giovanni Ferraro[b], Emiliano Fratini[b], Luca Valbonetti[a], Clemencia Chaves Copez[a,*], Dario Compagnone[a]



Metal nanoparticles formation

Phenolic content and antioxidant capacity evaluation trough Au and AgNPs formation


sensors MDPI

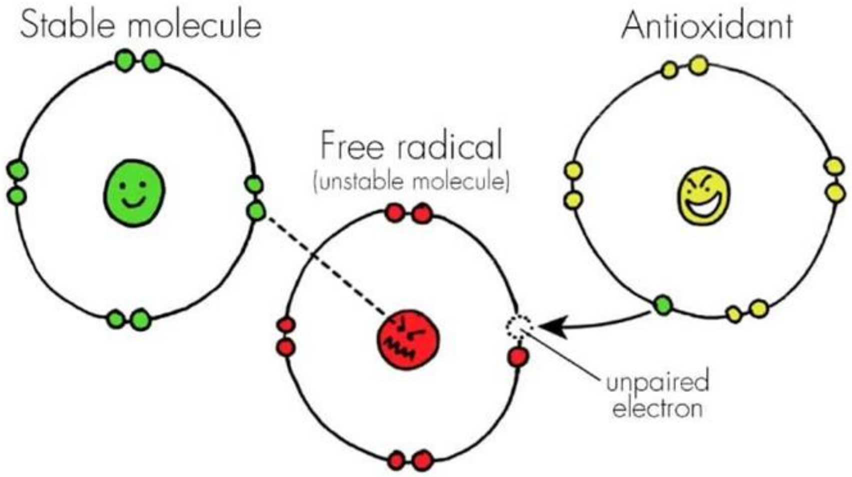
Review

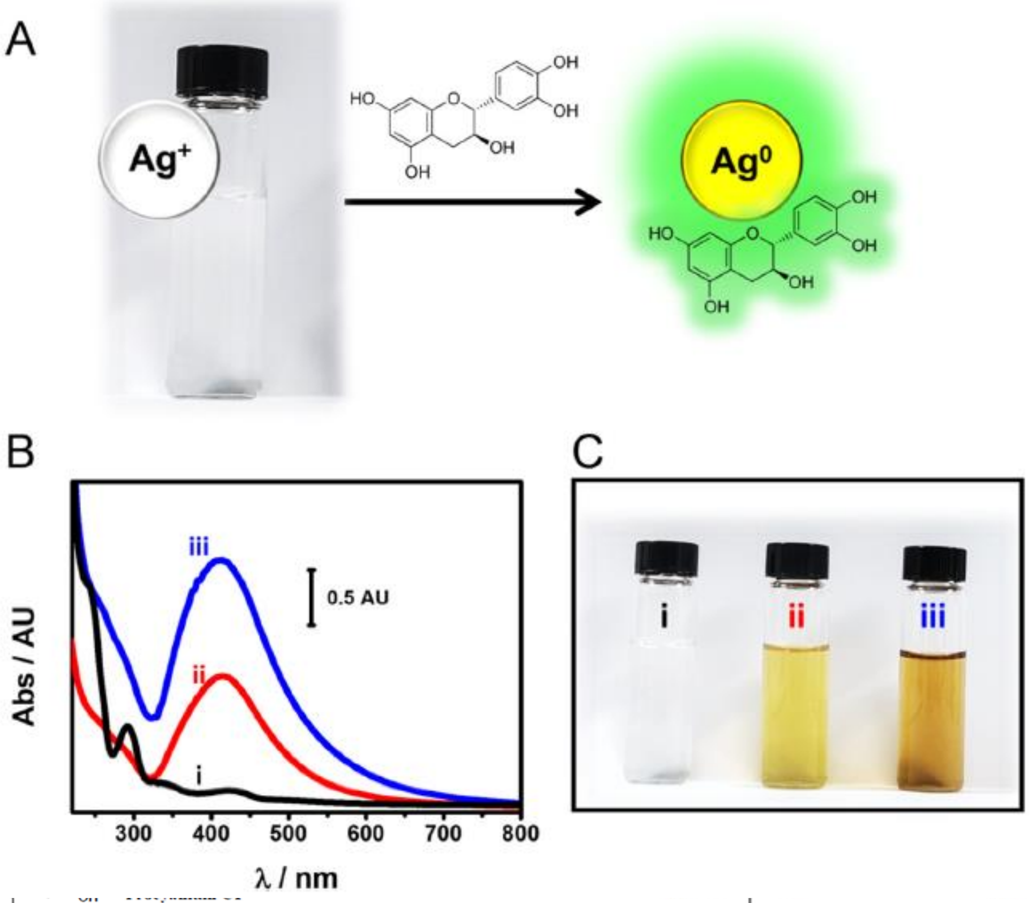
Nanomaterial-Based Sensing and Biosensing of Phenolic Compounds and Related Antioxidant Capacity in Food

Flavio Della Pelle and Dario Compagnone *

… Nanomaterial-based method for estimating the antioxidant activity relies on the polyphenol-mediated growth of MNPs (AuNPs and AgNPs), and optical monitoring of the corresponding plasmon absorption bands…

SCAMPICCHIO, Matteo, et al. Nanoparticle-based assays of antioxidant activity. *Analytical chemistry*, 2006, 78.6: 2060-2063.

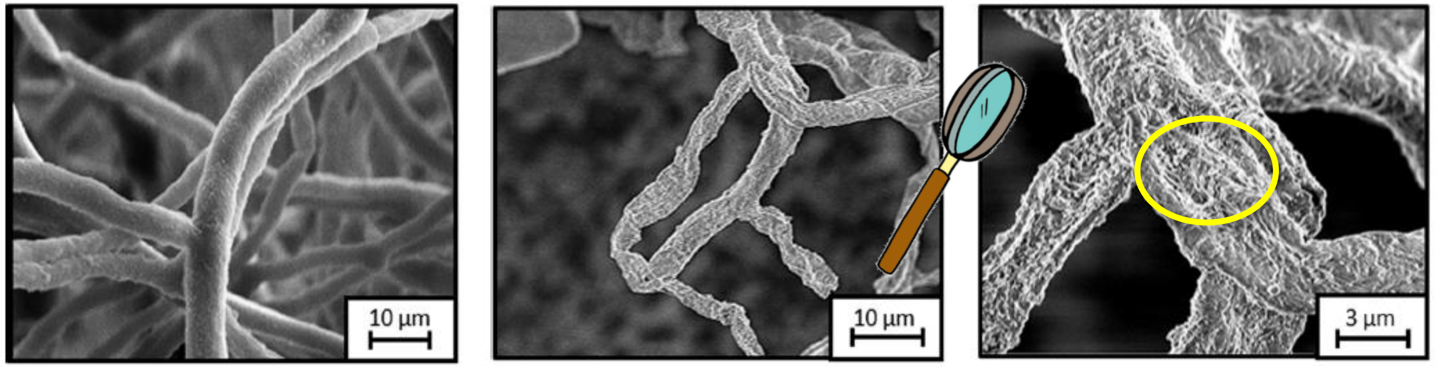




MNPs as antimicrobial agent: AgNPs' antifungal performances

Hyphae interaction

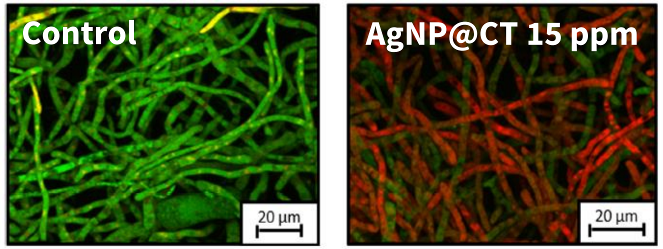
Control **AgNP@CT 15 ppm**



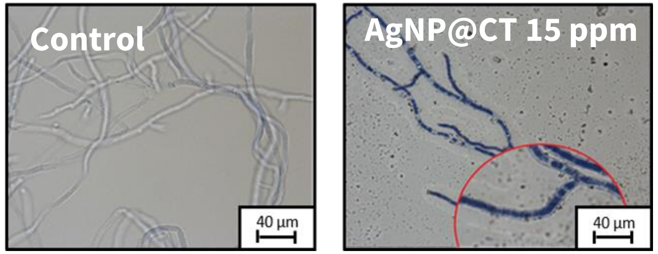
HYPOTHESIS:

- AgNPs adhesion
- Membrane damages
- Hyphae necrosis

Live and death kit assay



Evans blue assay



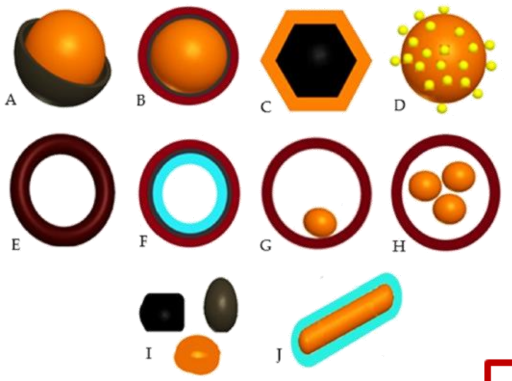
higher — EFFECT — lower

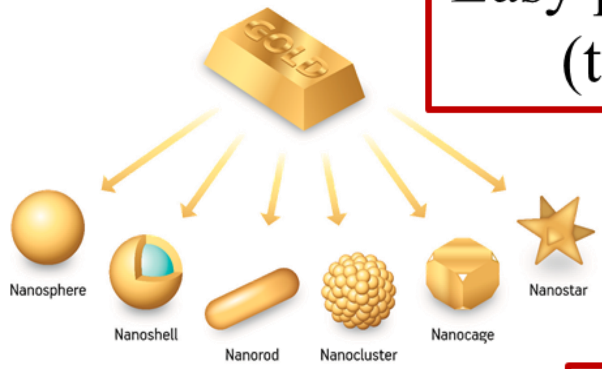
AgNPs@CT

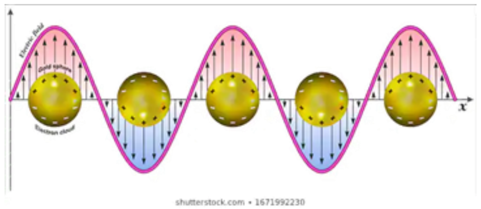
AgNPs@CF

AgNPs@MY ~ AgNPs@GL

Advantages of metal nanoparticles for analyitical purposes

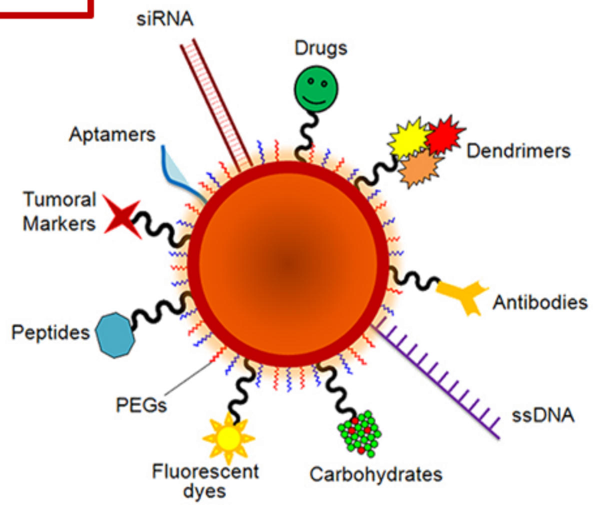




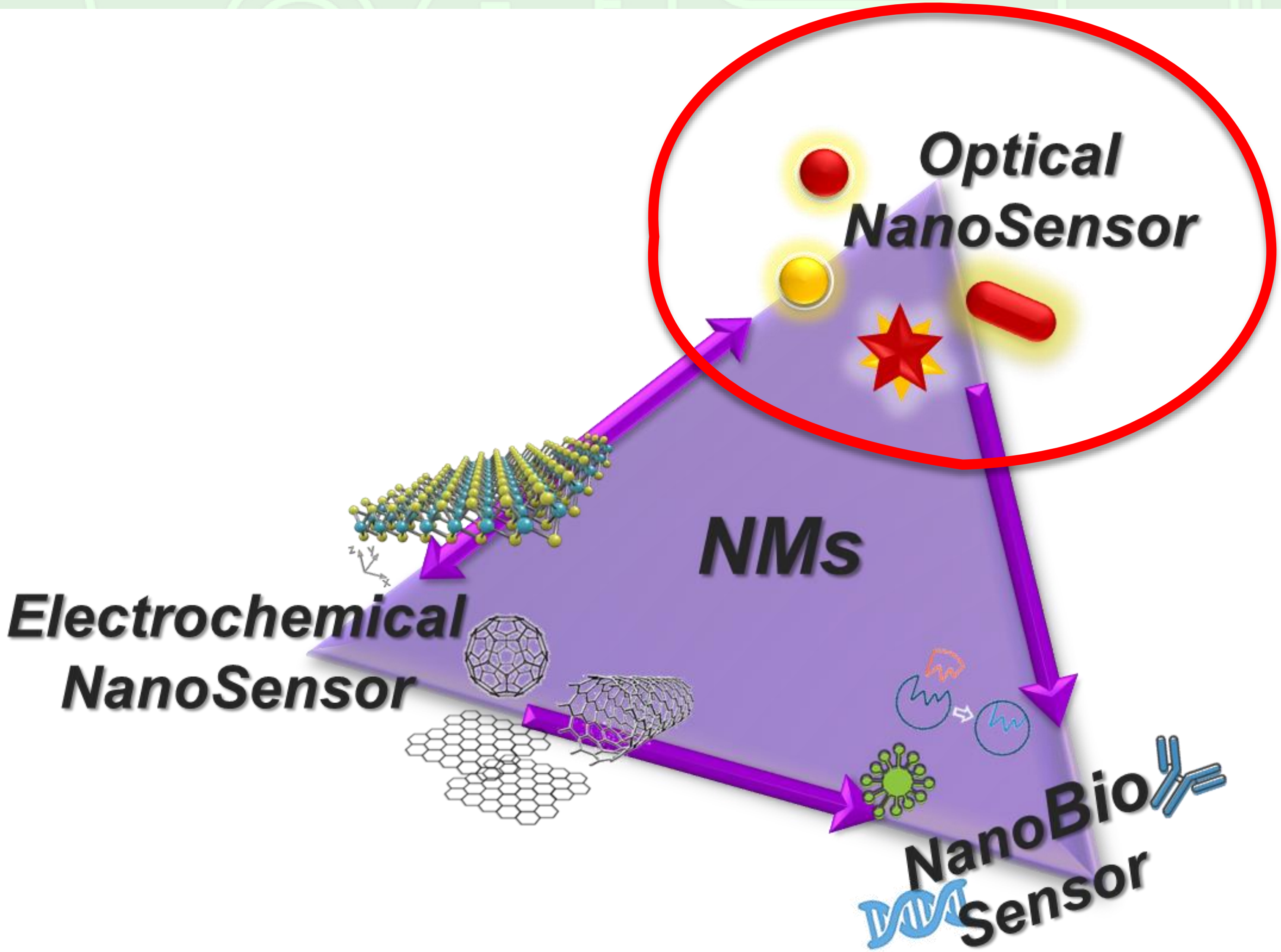


MNPs

- Nano
- High conductivity
- Robust / stable *(Inhert)*
- Surface (Bio)functionalization
- Good biocompatibility
- Easy preparation (tunable)



Nanoparticles in analytical chemistry and food analysis



MNPs and (L)SPR

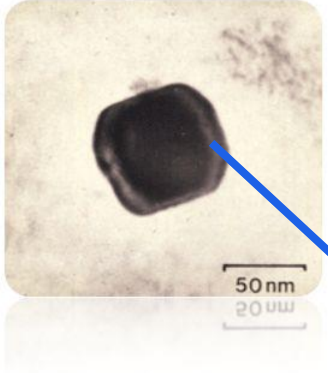
Metal nanoparticles

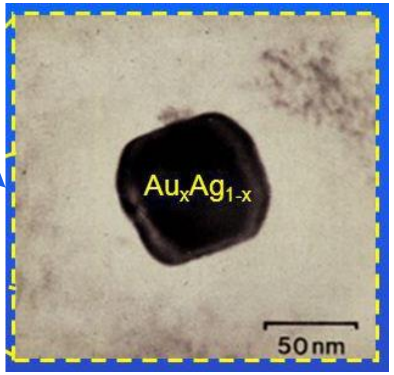
From Romans…

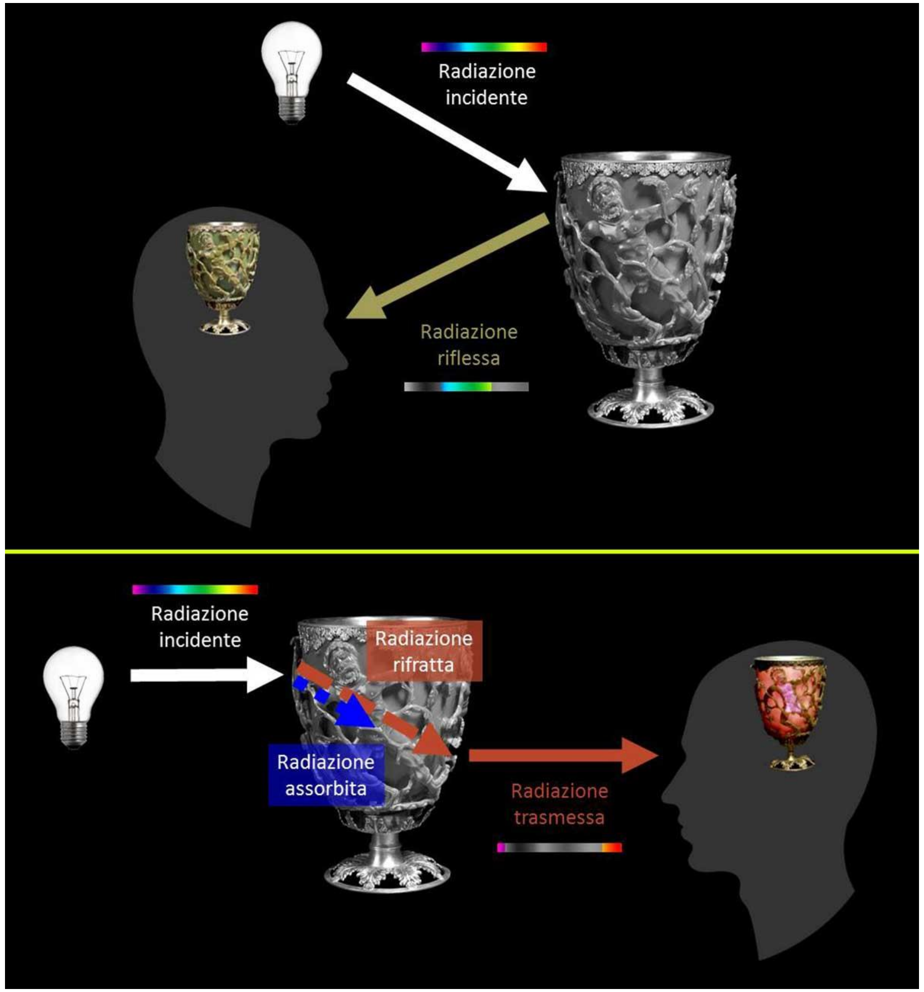
Nanotecnologia romana

I colori cangianti della Coppa di Licurgo, datata IV secolo a.C., sono dovuti a nanoparticelle di oro e argento disperse nella matrice vetrosa.


(Coppa di Licurgo, British Museum)



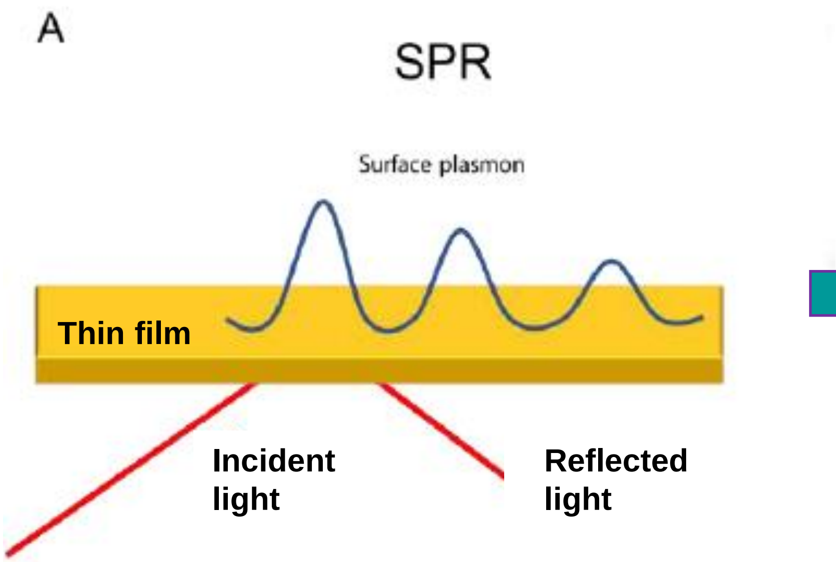


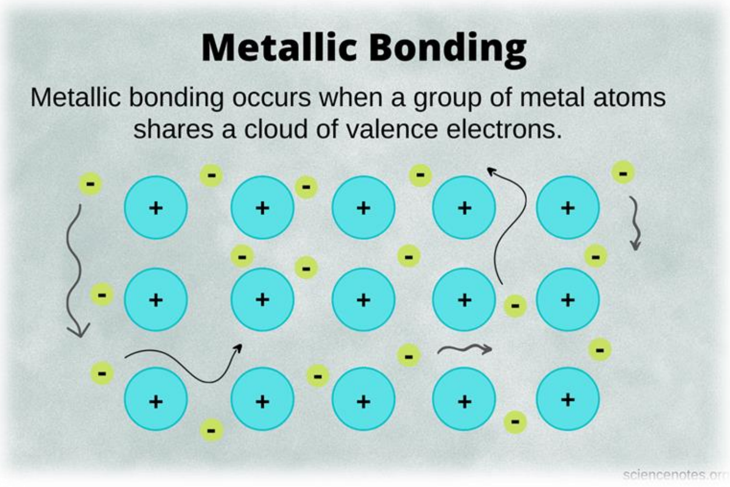


Novoselov, K. S., **Geim**, A. K., Morozov, S. V., Jiang, D. A., Zhang, Y., Dubonos, S. V., ... & Firsov, A. A. (**2004**). *science*, *306*(5696), 666-669.

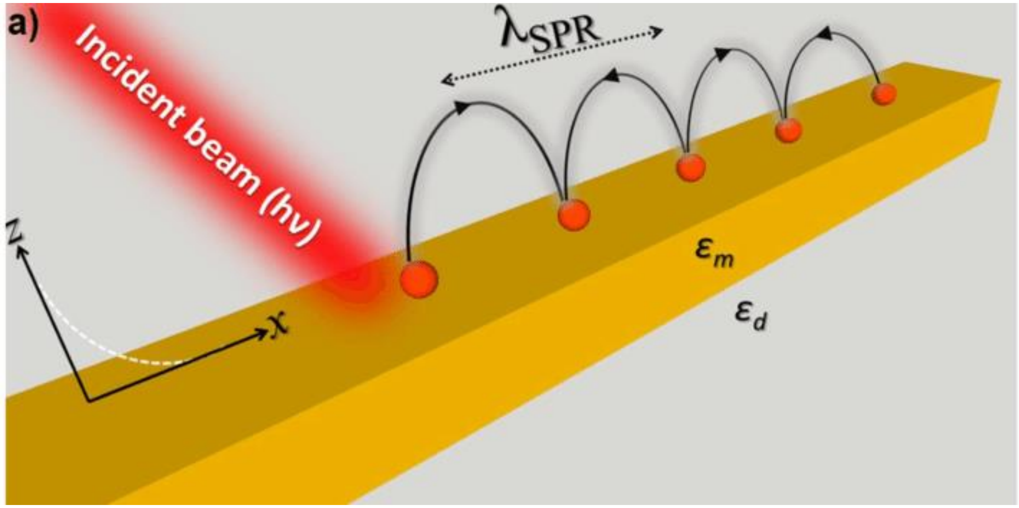
Plasmonic-active nanostructured materials for sensing and biosensing

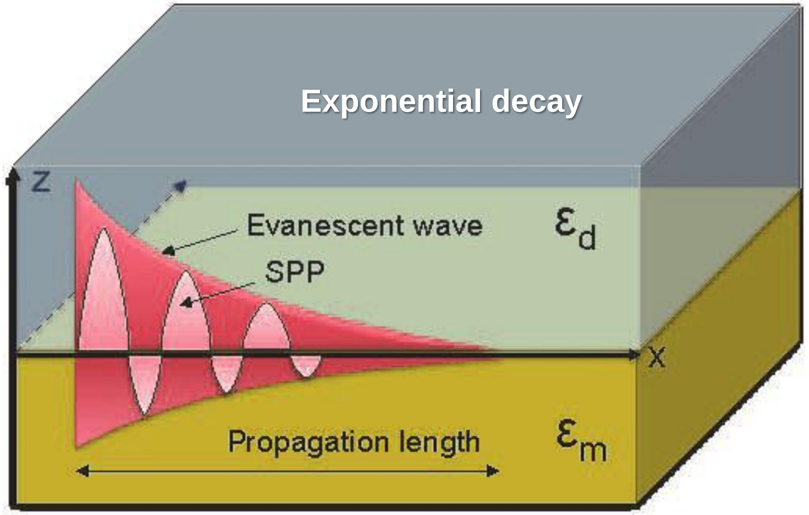
Surface plasmon resonance (SPR) is a phenomenon where the electrons in the metal surface layer are excited by photons of incident light with a certain angle of incidence, and then propagate parallel to the metal surface (Zeng et al., 2017)



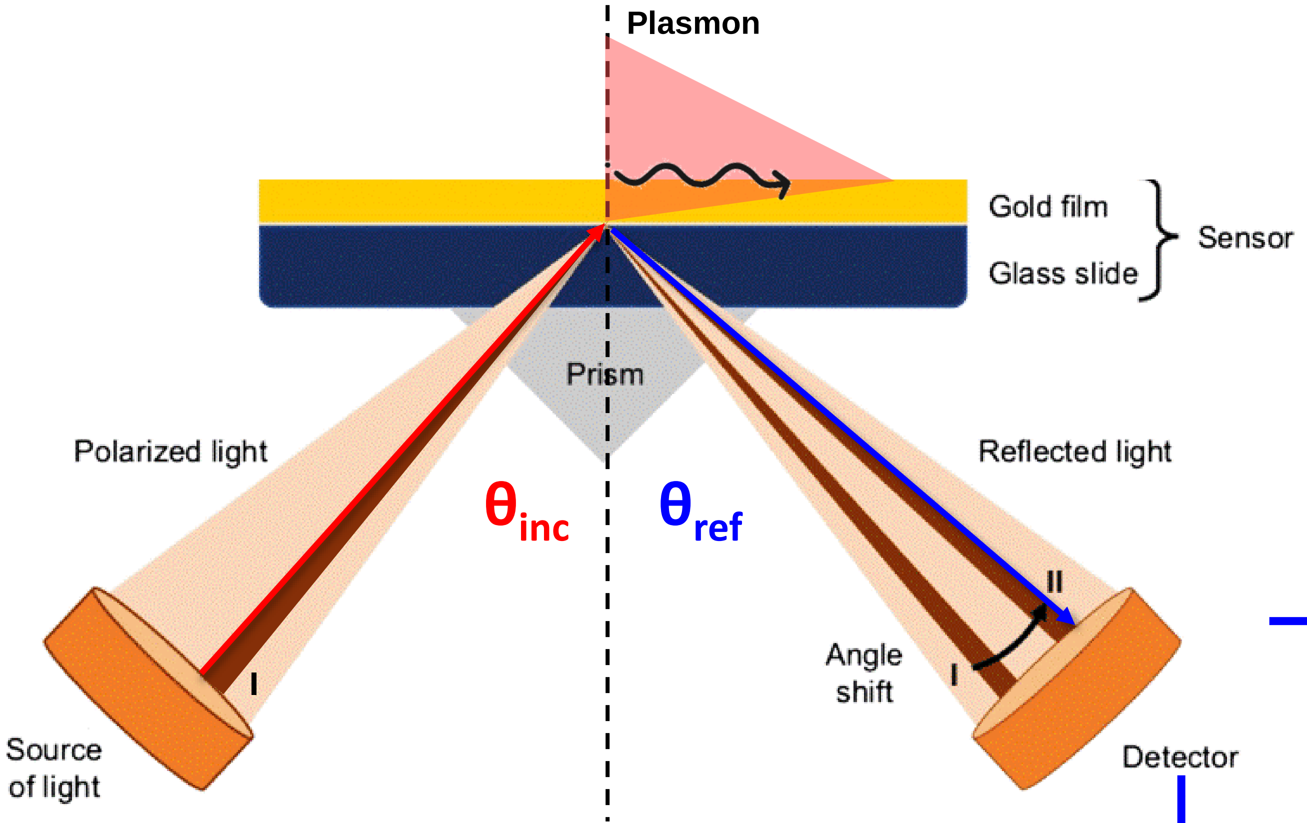


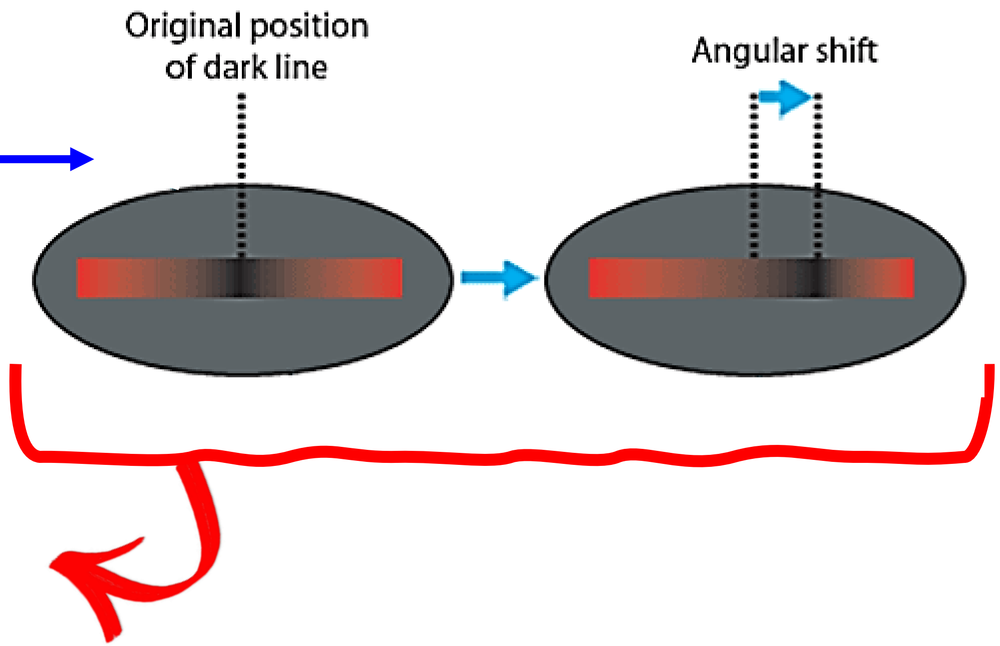
Electromagnetic/Evanescent wave



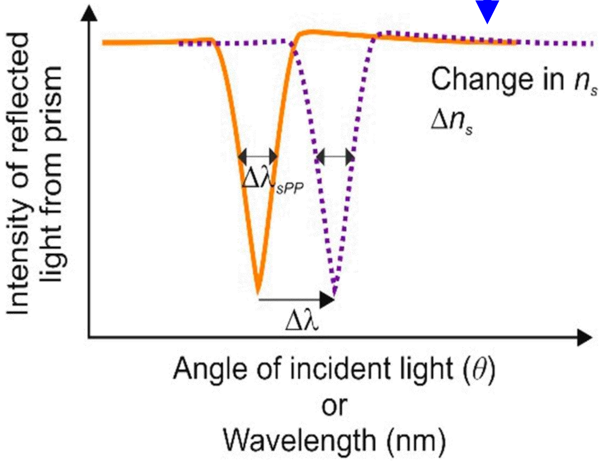


Plasmonic-active nanostructured materials for sensing and biosensing

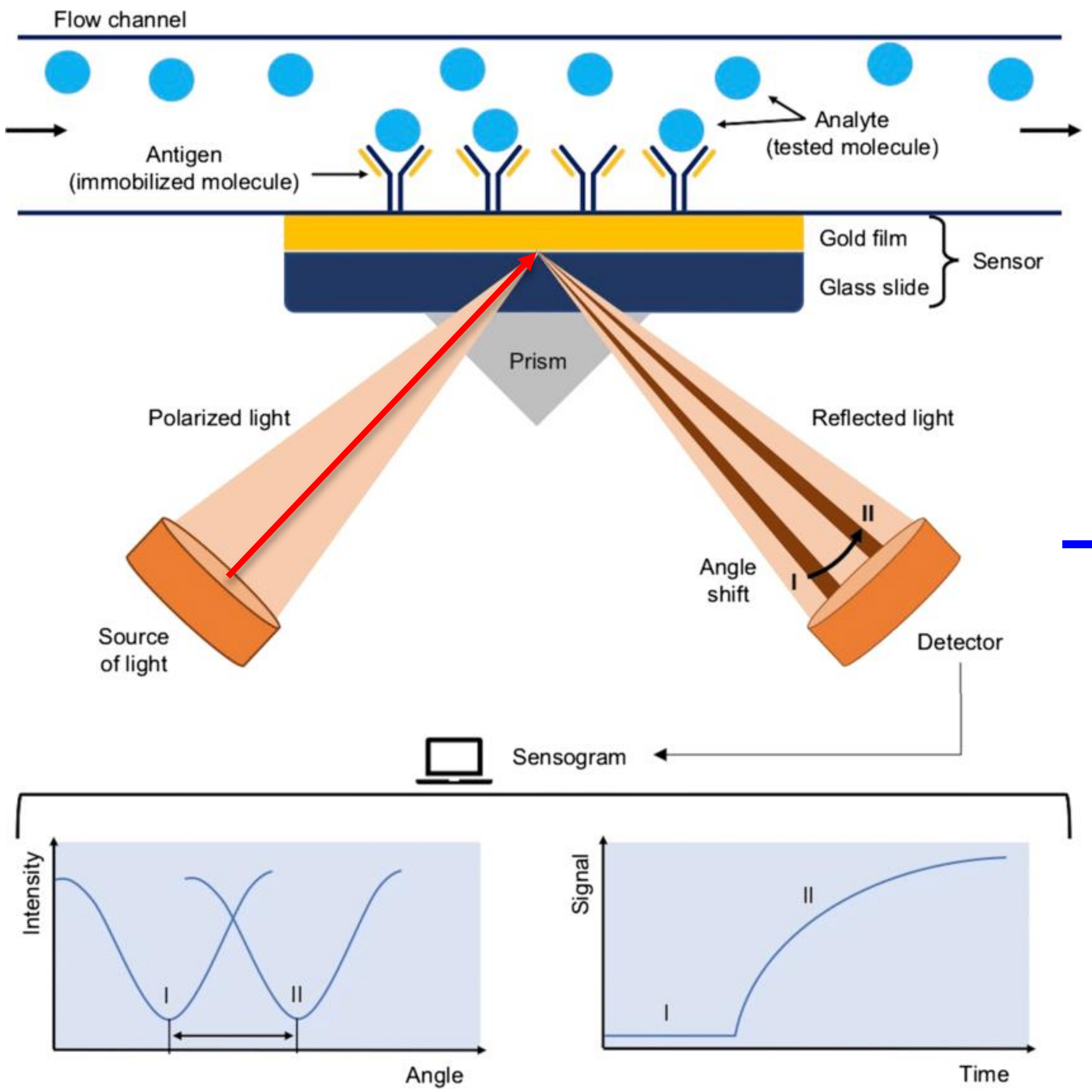


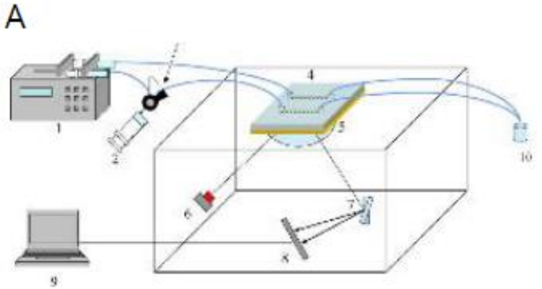


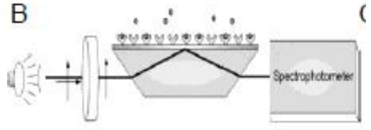
- At θ_{SPR}, the reflected light intensity decreases and this difference is measured in SPR.
- This variation can be trasduced by Refractive Index/ $\theta_{inc/SPR}$ or wavelength (λ_{SPR}) variation.



Plasmonic-active nanostructured materials for sensing and biosensing

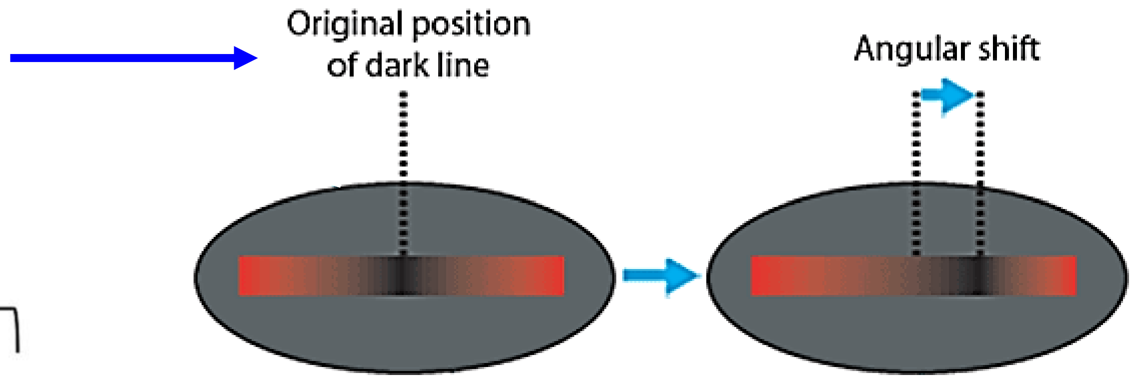




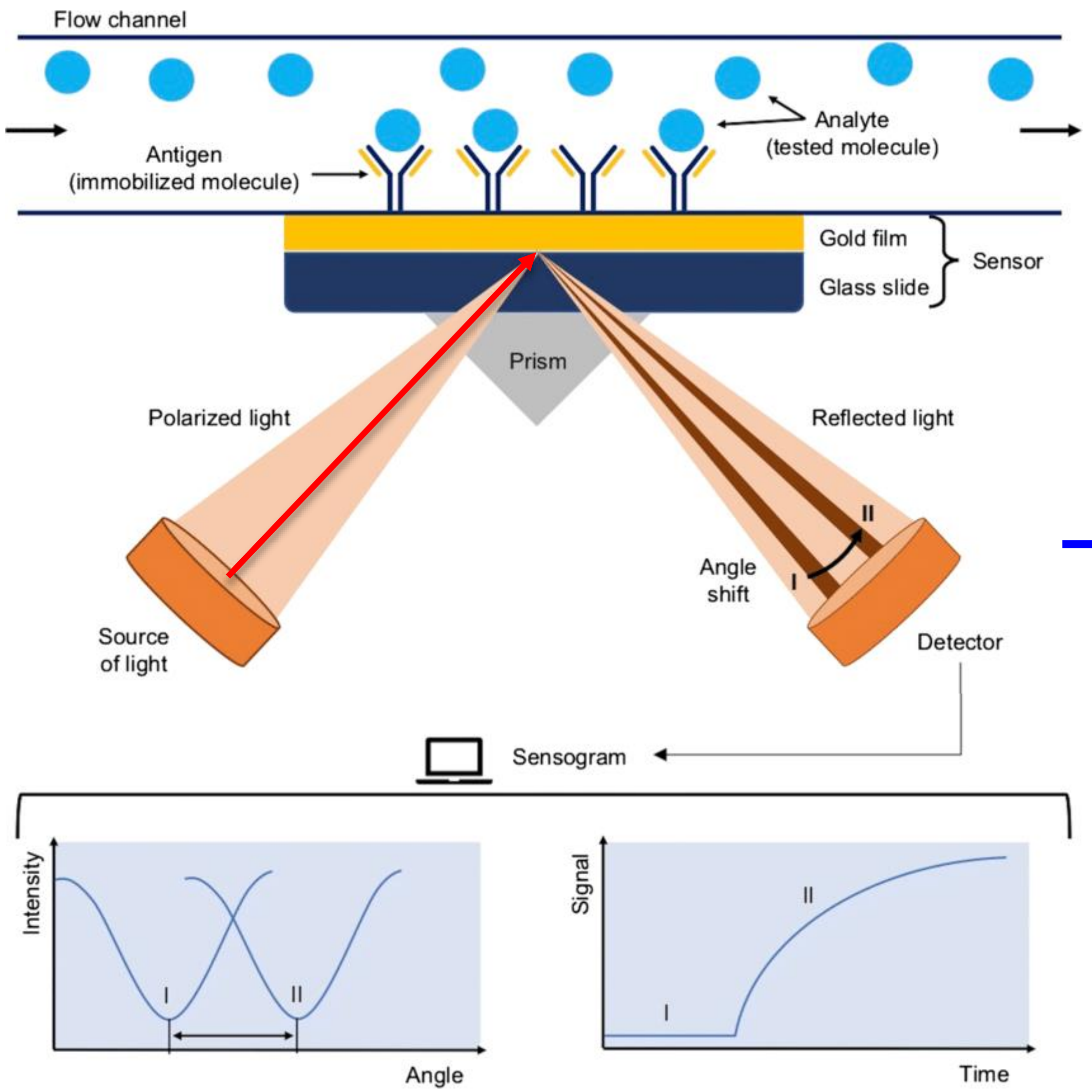


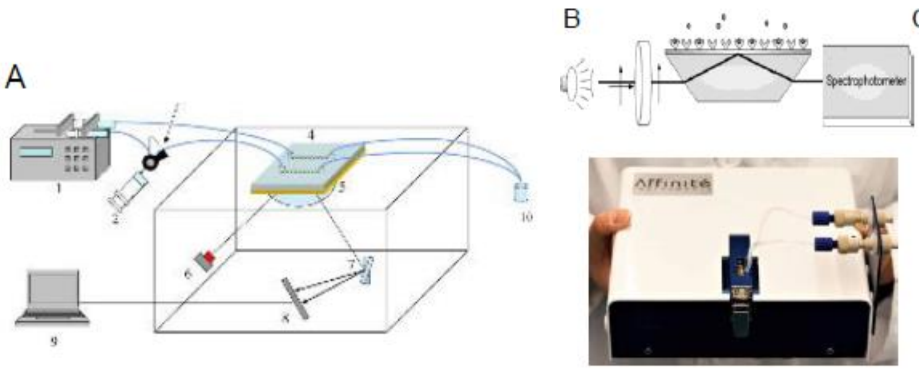
Portable multi-wavelength SPR

SPR-based sensing strategy



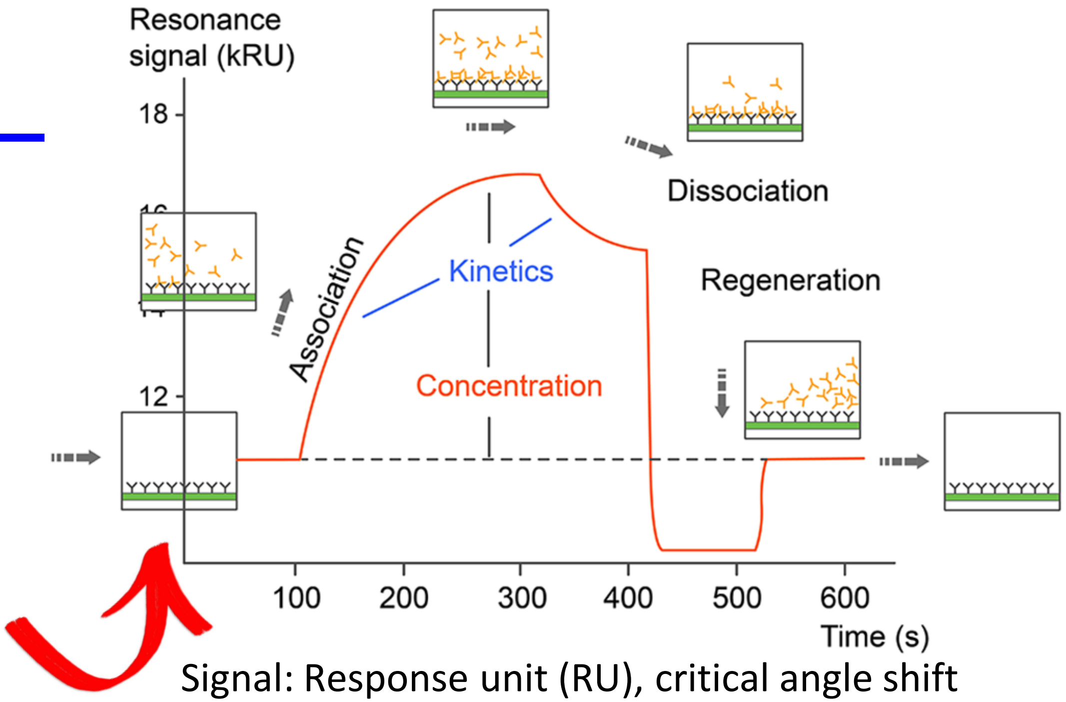
Plasmonic-active nanostructured materials for sensing and biosensing





Portable multi-wavelength SPR

SPR-based sensing strategy



Signal: Response unit (RU), critical angle shift

MNPs and (L)SPR

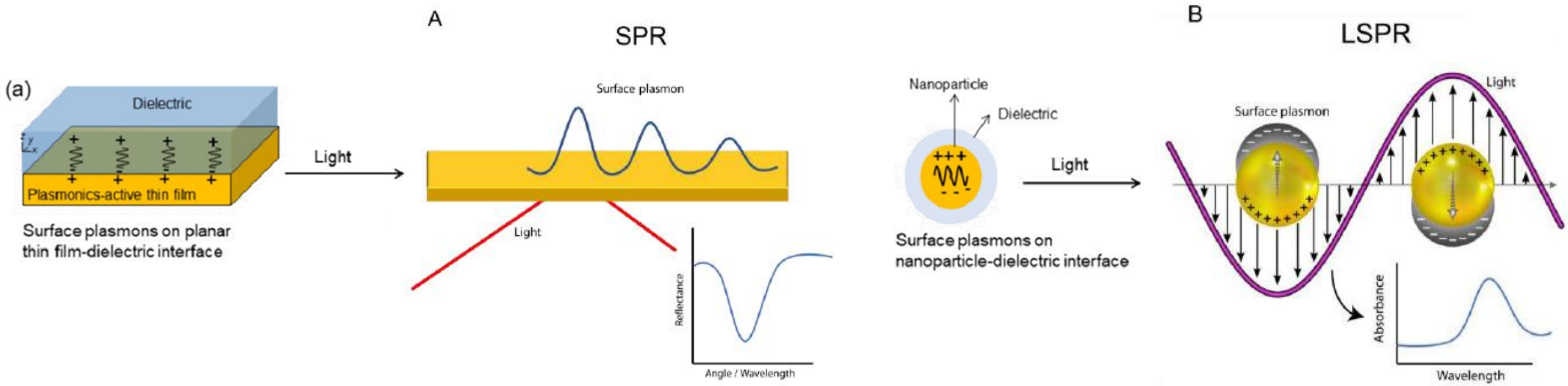
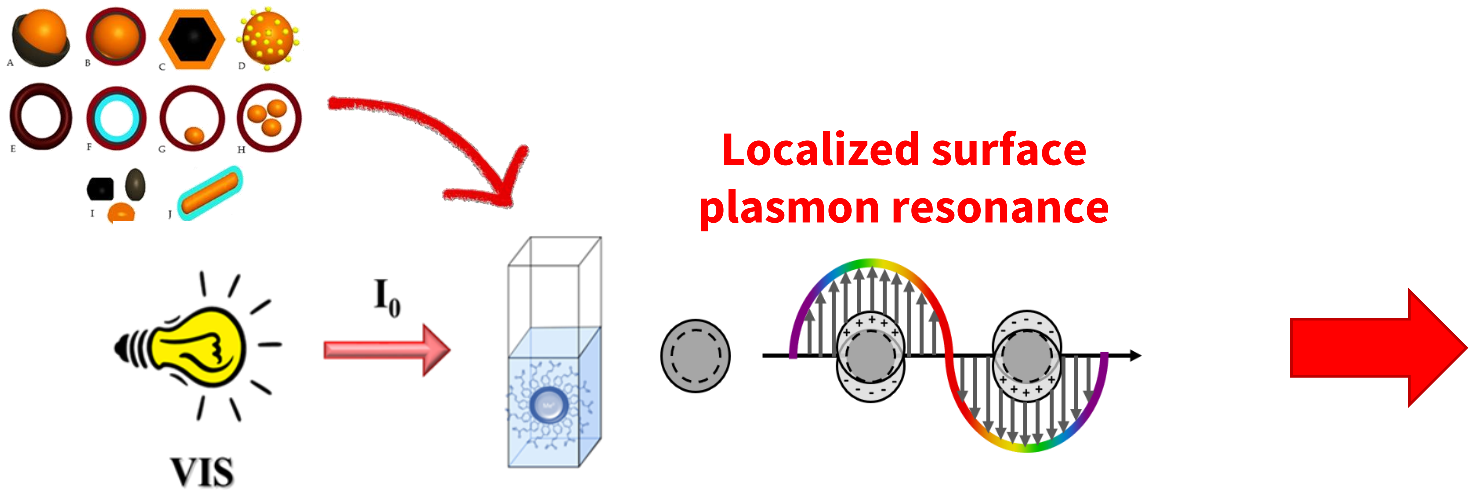
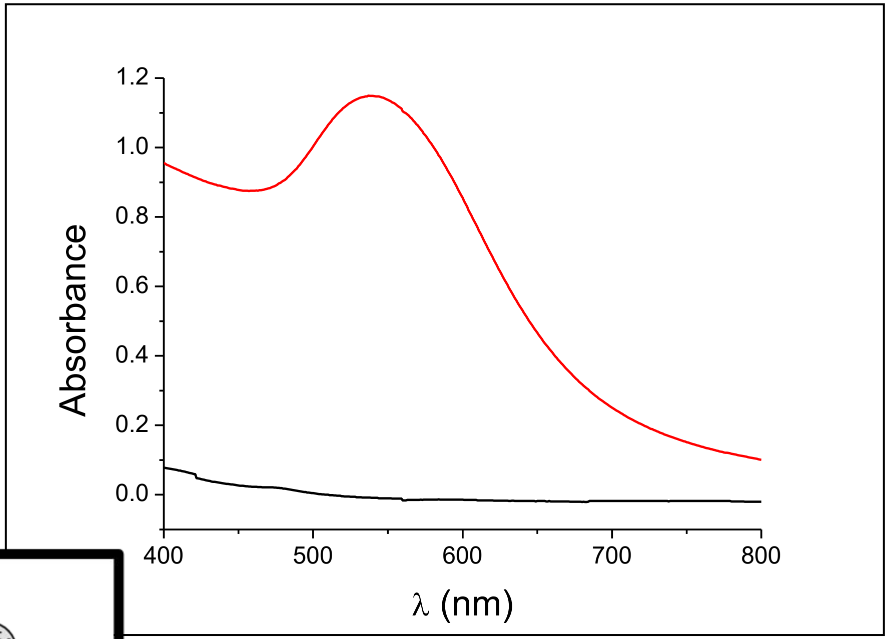
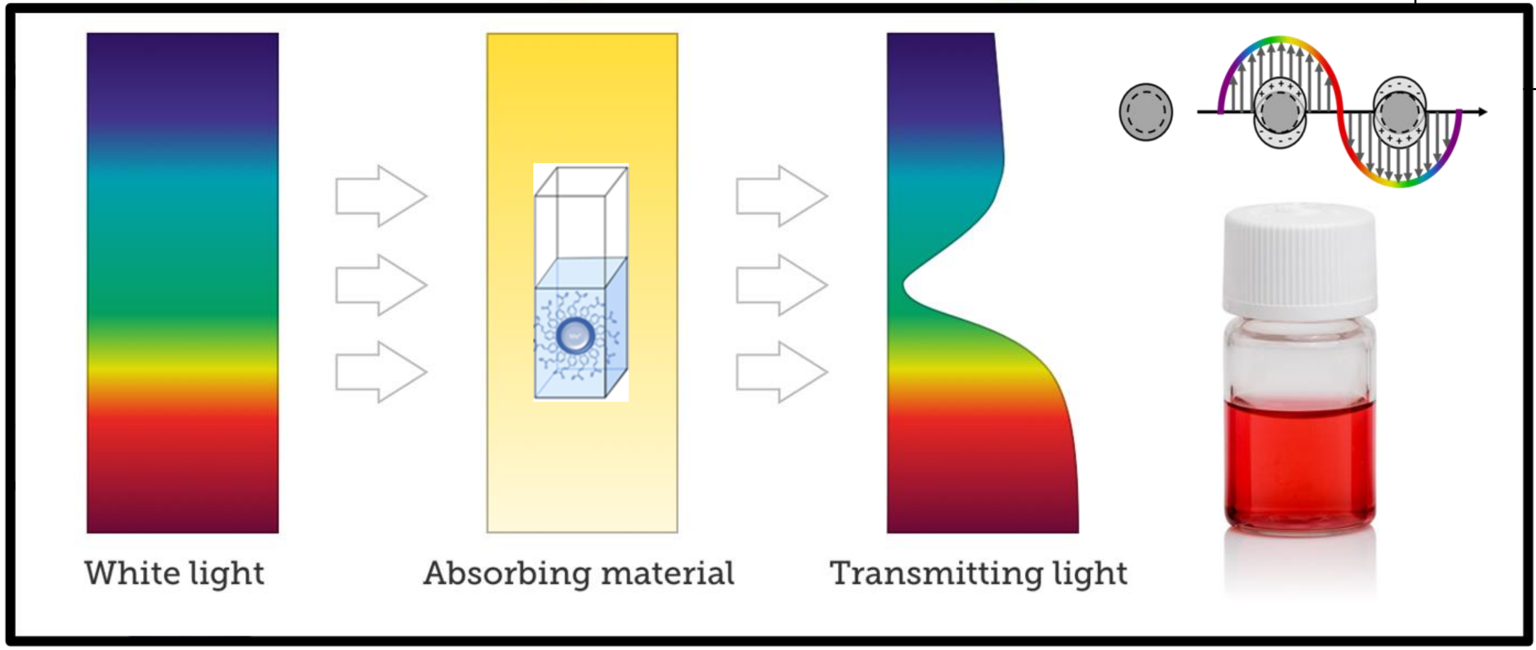


Figure 1. A) Prism coupling configuration of SPR, where a light beam impinges on a thin metallic film deposited on a prism. P-polarized light absorbed by the surface plasmon is seen from a minimum in the reflection spectra. B) Representation of the localized surface plasmon on nanoparticles and absorbance spectra obtained for binding events on nanoparticles.

Localized Surface Plasmon Resonance (LSPR)

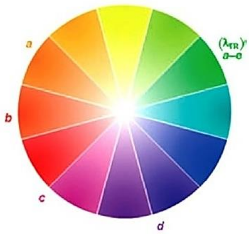






MNPs and LSPR

Metal nanoparticles: their camaleontic features

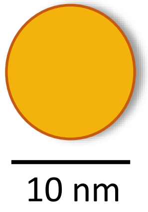


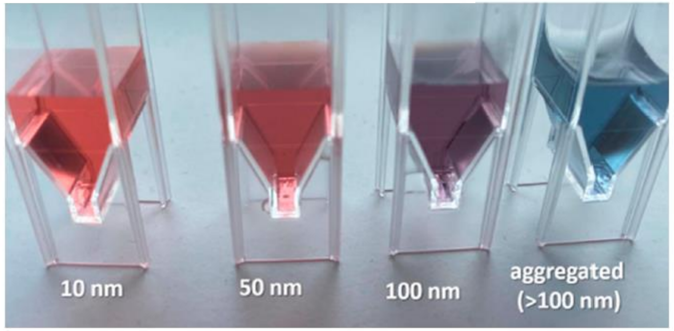
MNPs can interact in different ways VIS-electromagnetic radiation depen on their shapes, sizes, and compositi

Gold nanoparticles

Diameter

size

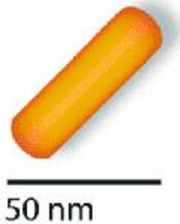


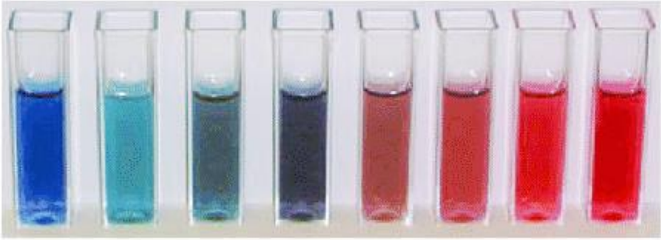


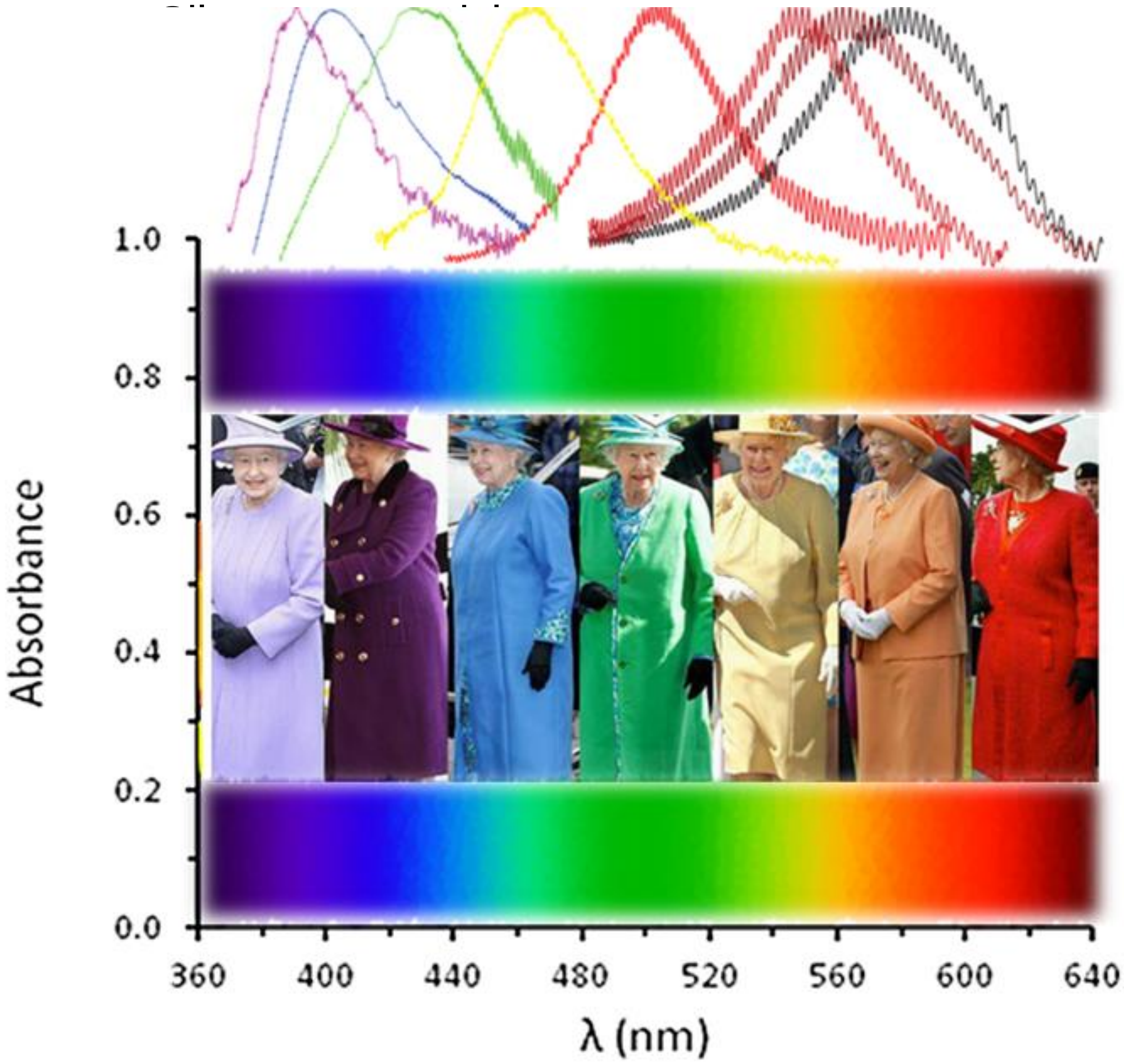
Gold nanorods

Nanorods

aspect ratio

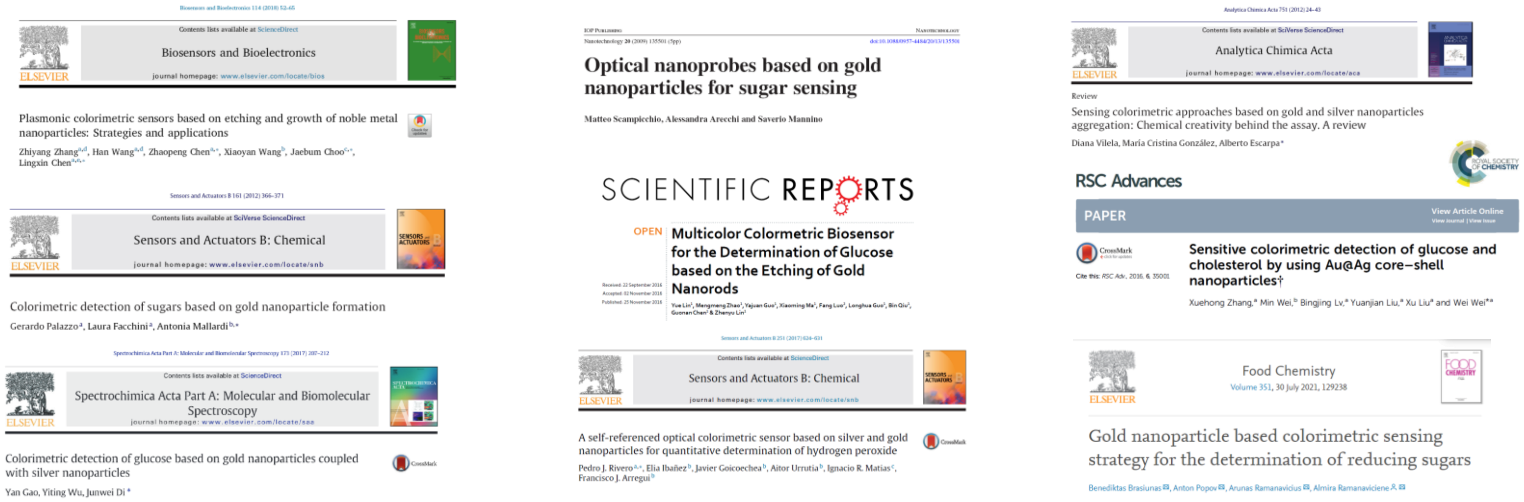




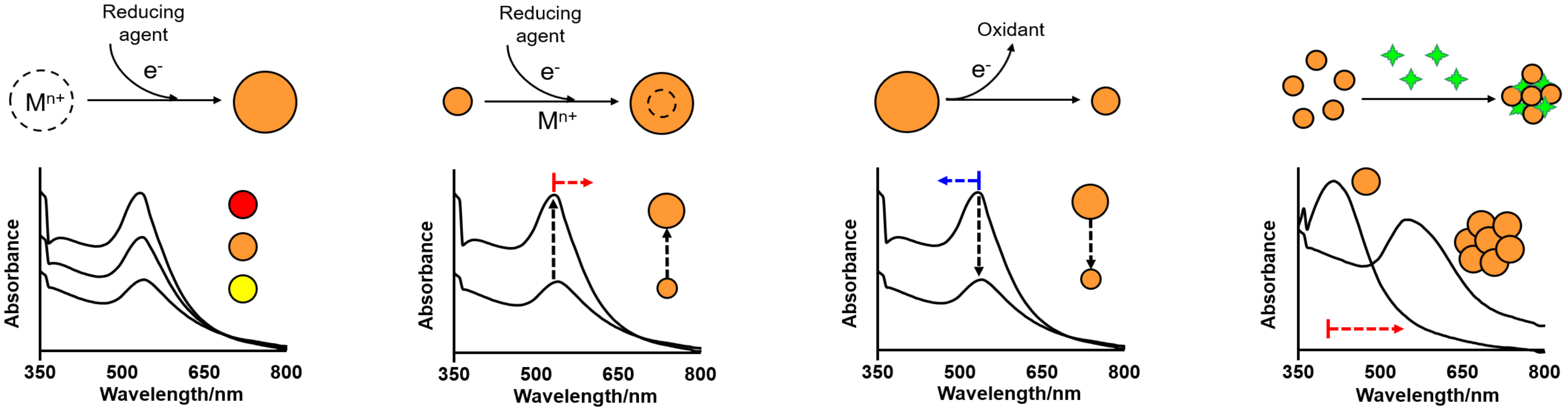


Plasmonic-active nanostructured materials for sensing and biosensing

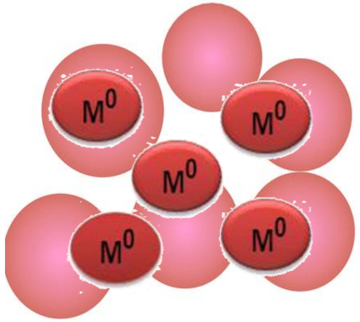
Colloidal
metal nanoparticles
based assays

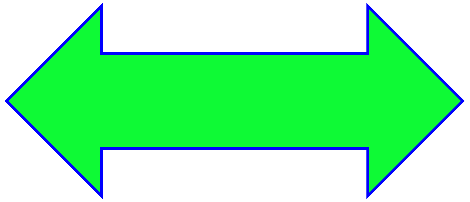


Localized Surface Plasmon Resonance

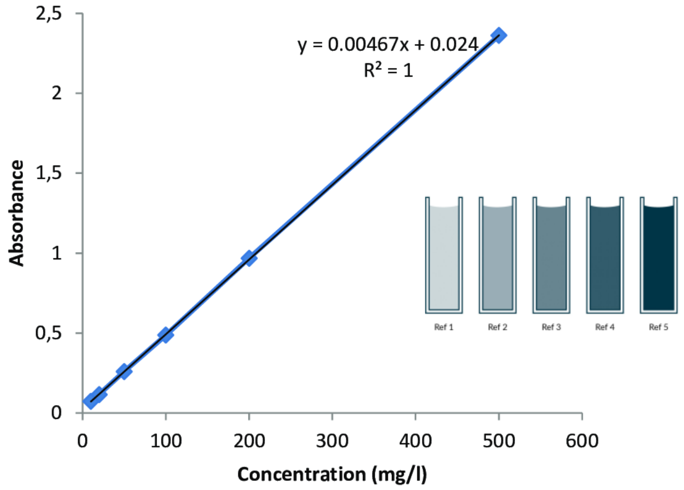


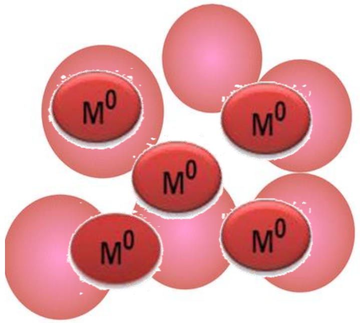
Plasmonic-active nanostructured materials for sensing and biosensing

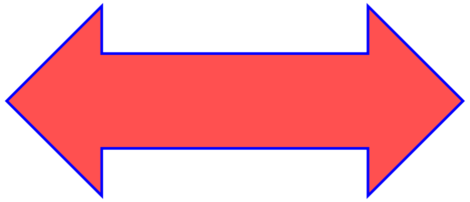




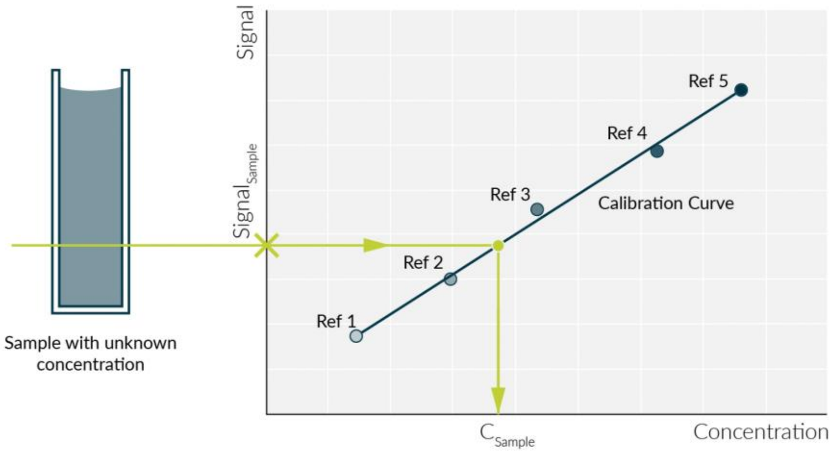
MODEL SYSTEM (STANDARD)



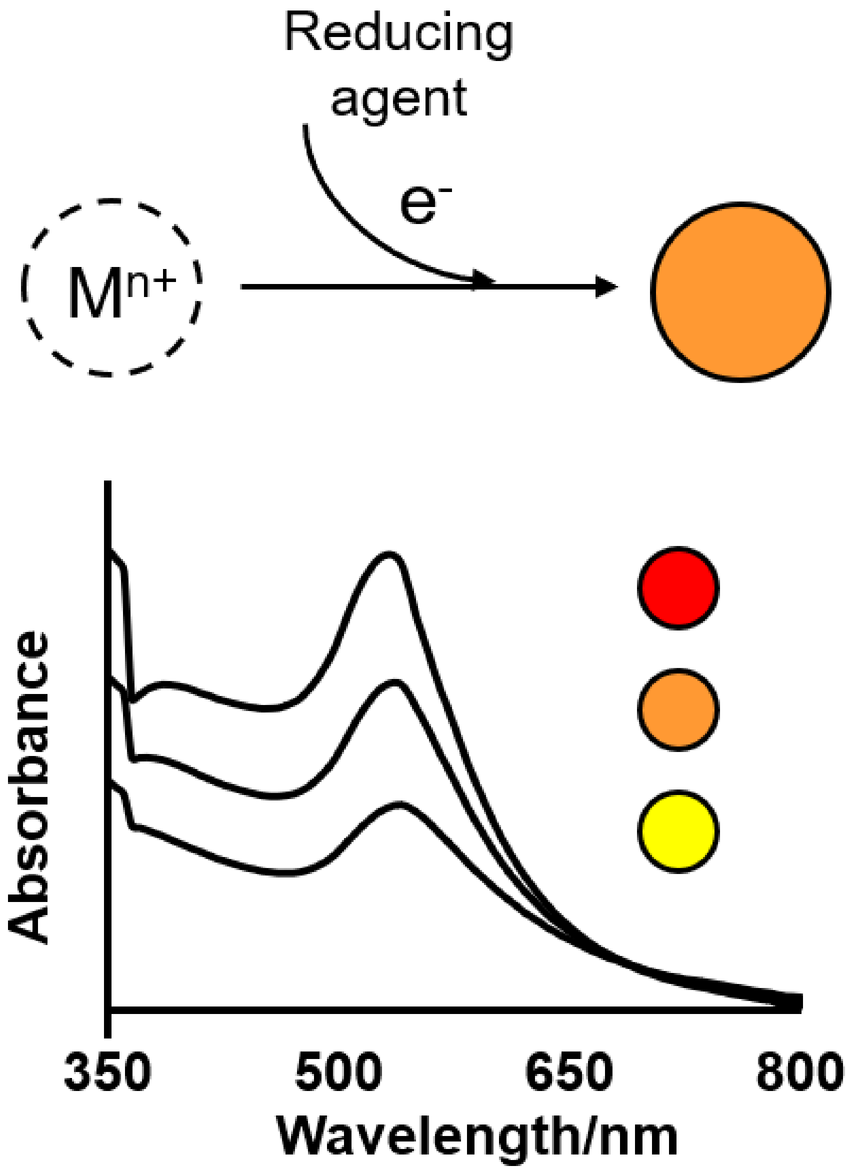




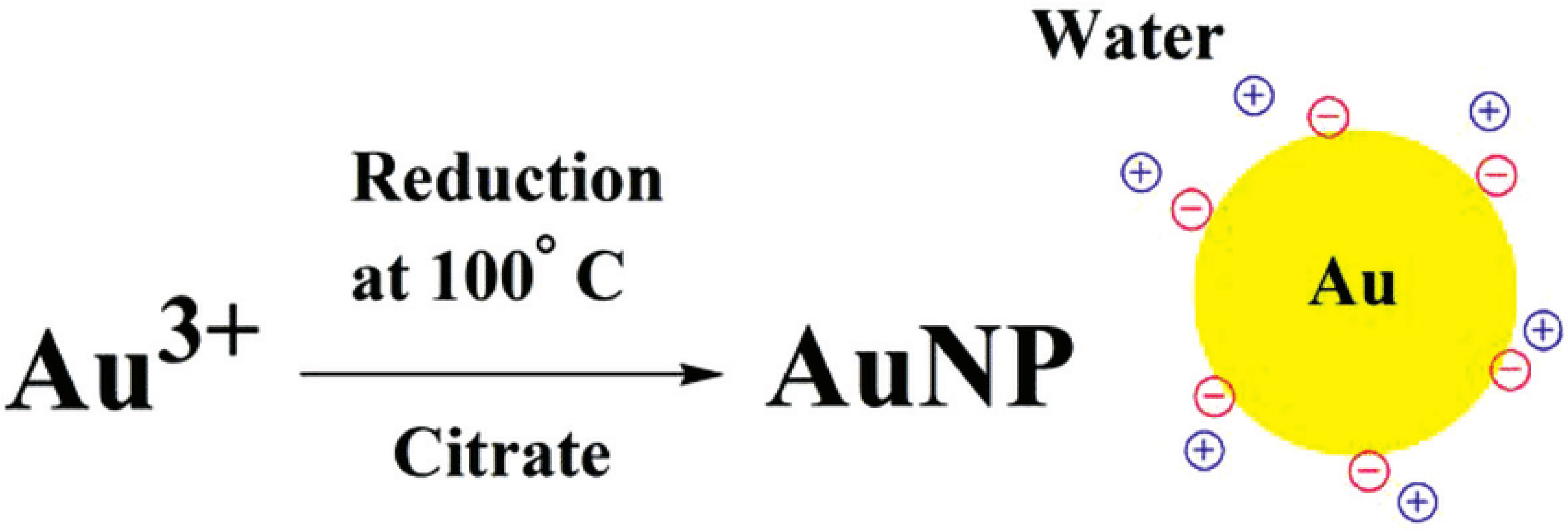
SAMPLE

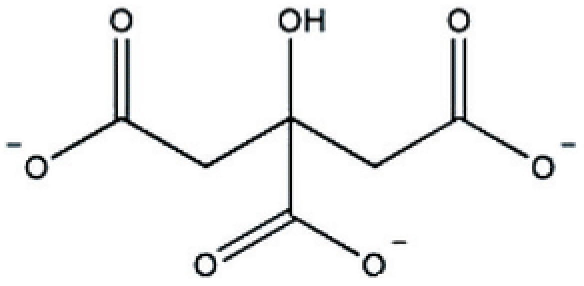


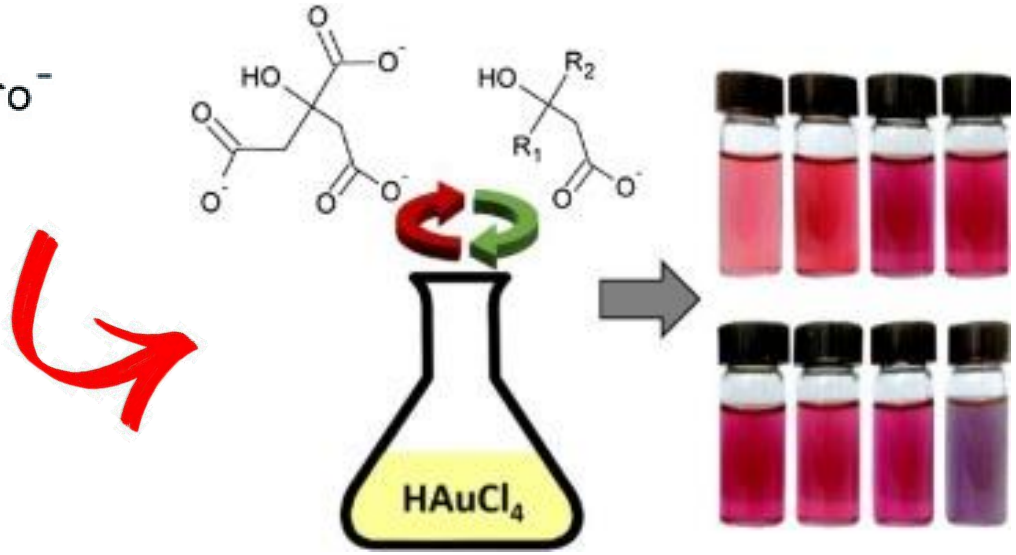
Metal nanoparticles formation



Metal nanoparticles formation.



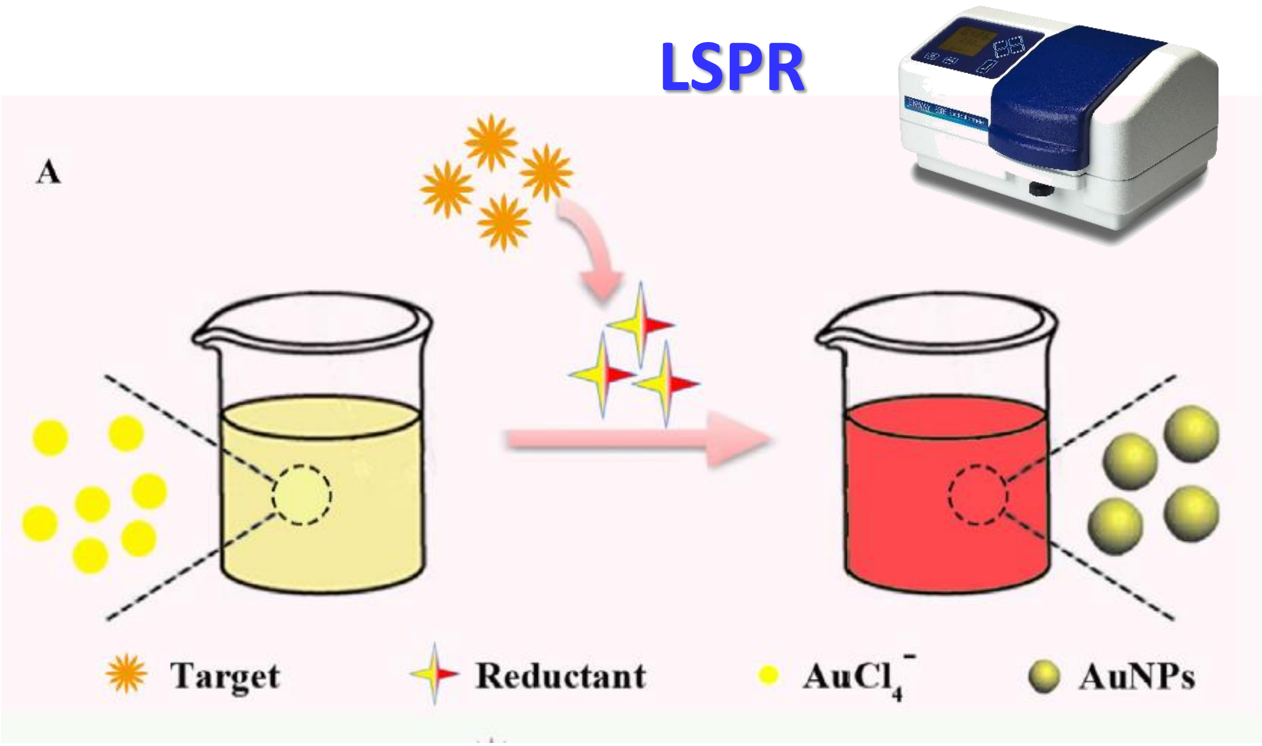




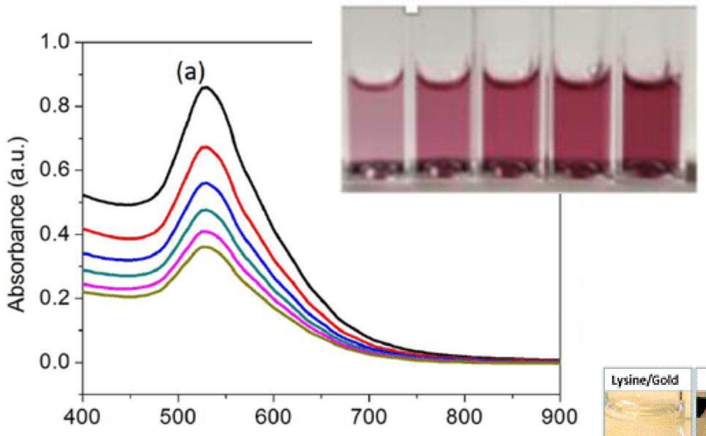
Metal nanoparticles formation.

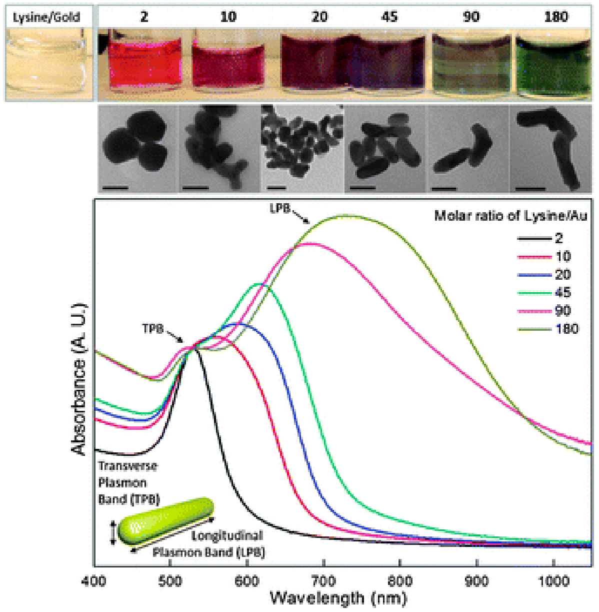
Main strategy

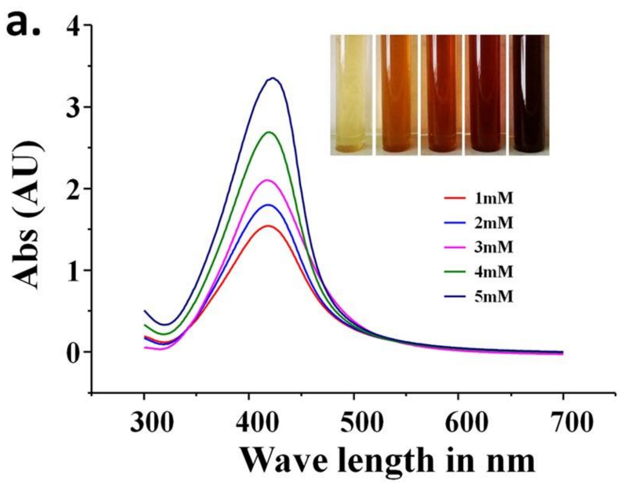
LSPR



Analytical signal

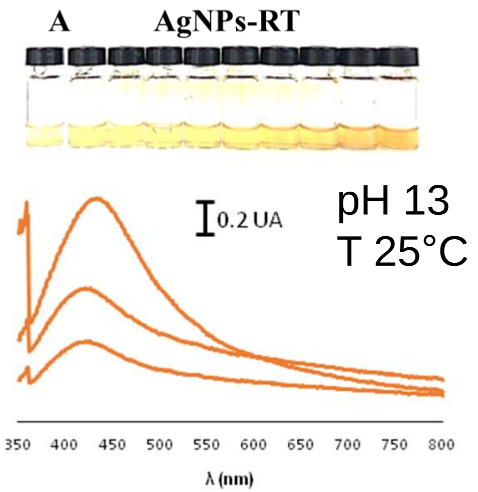


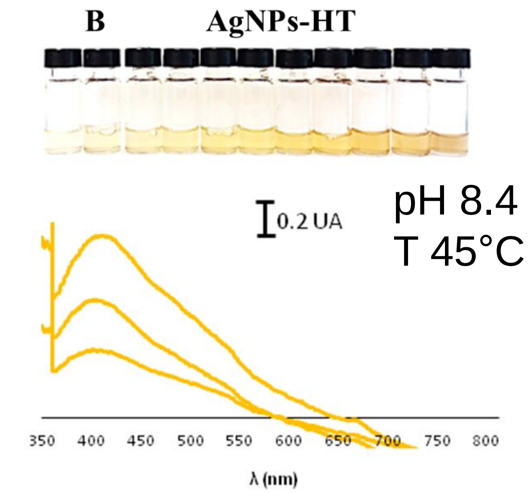


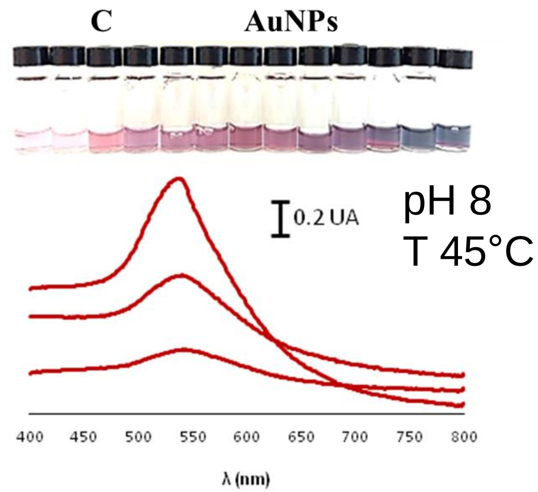


Metal nanoparticles formation

Phenolic content and antioxidant capacity evaluation trough Au and AgNPs formation



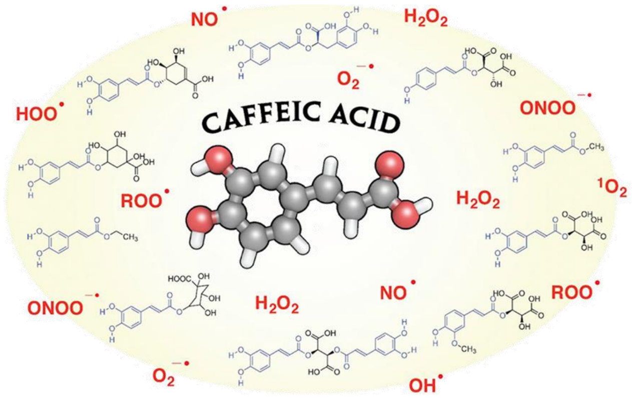


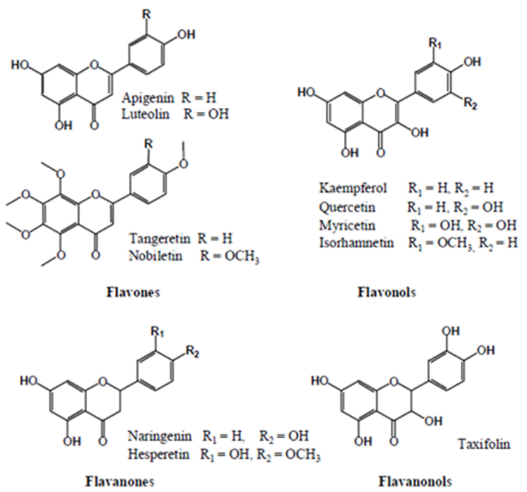


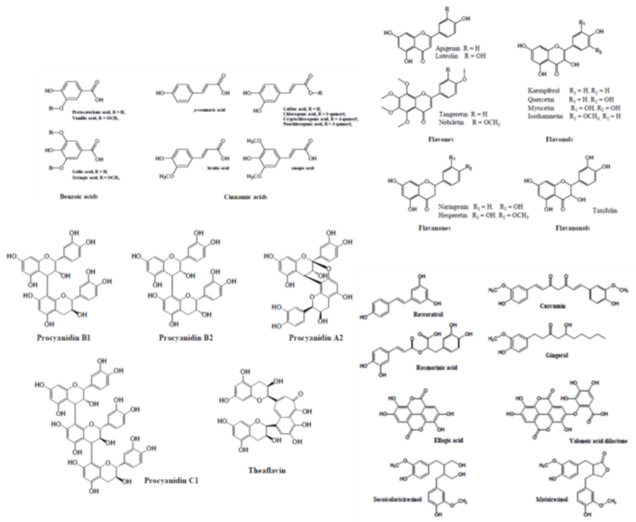
Antioxidant Capacity

Class Selective

Total phenolic content







Metal nanoparticles formation

Phenolic content and antioxidant capacity evaluation trough Au and AgNPs formation

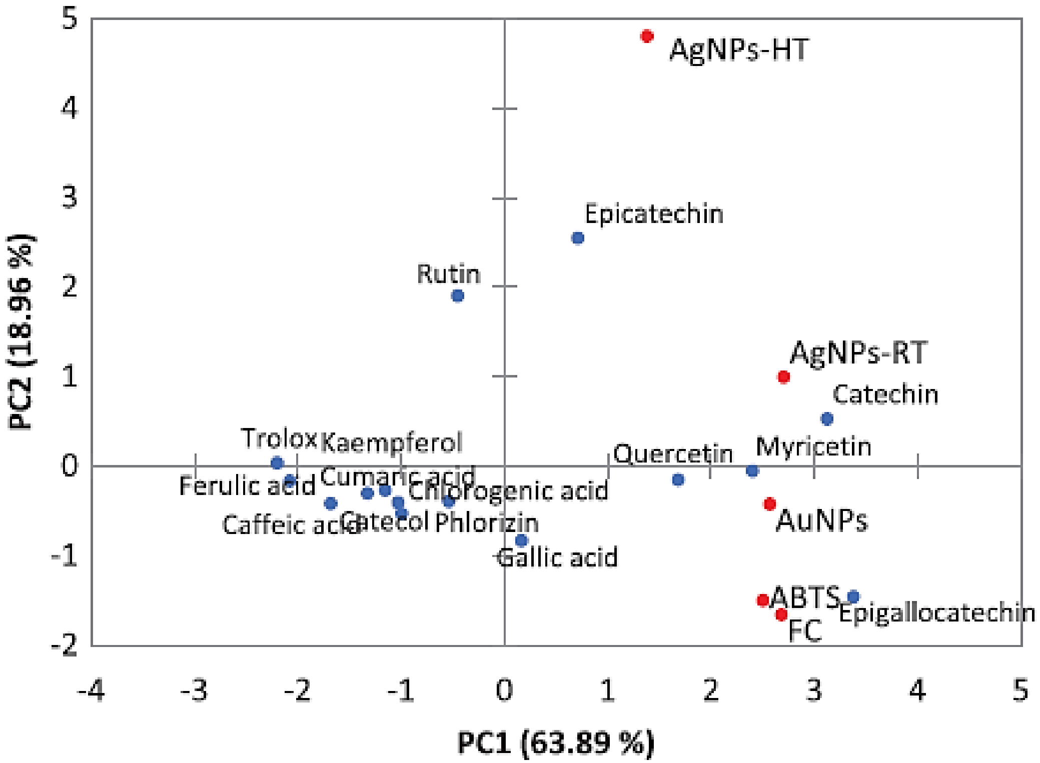
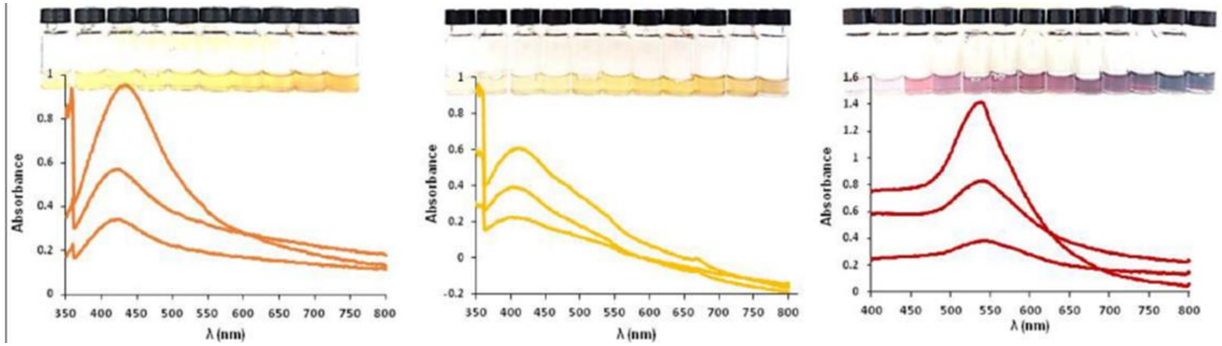


Fig. 2. PCA of the ABTS, FC, AuNPs and the proposed AgNPs-based methods reactivity vs. polyphenolic compounds. The biplot (Score and loading) of the first two principal components showed 82.85% of the cumulative variance. Rows normalization were applied to the dataset. Data were autoscaled before PCA.

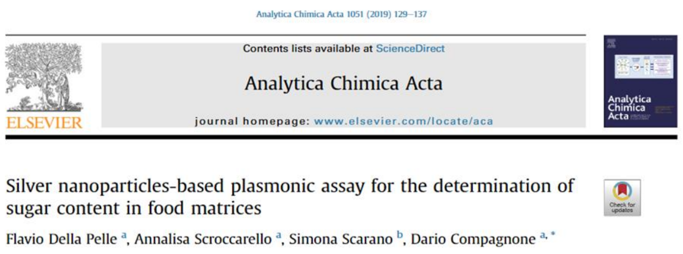
R	ABTS	FC	AgNPs-HT	AgNPs-RT	AuNPs
ABTS	1	0.876	0.891	0.956	0.977
FC	0.876	1	0.733	0.913	0.801
AgNPs-HT	0.891	0.733	1	0.770	0.826
AgNPs-RT	0.956	0.913	0.770	1	0.950
AuNPs	0.977	0.801	0.826	0.950	1



VT: Vanilla Tea
TG: Green Tea
TC: Classic Tea
SD: sogni d'oro infused
RE: Relax infused
RB: Rosa di bosco Infused
LT: Lemon Tea
IN: Finocchio infused
DIG: Digestiva infused

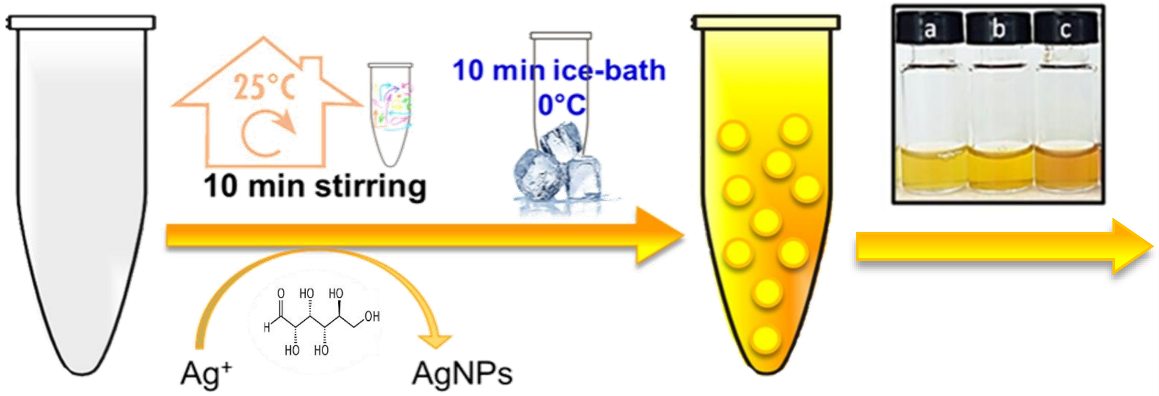
Metal nanoparticles formation

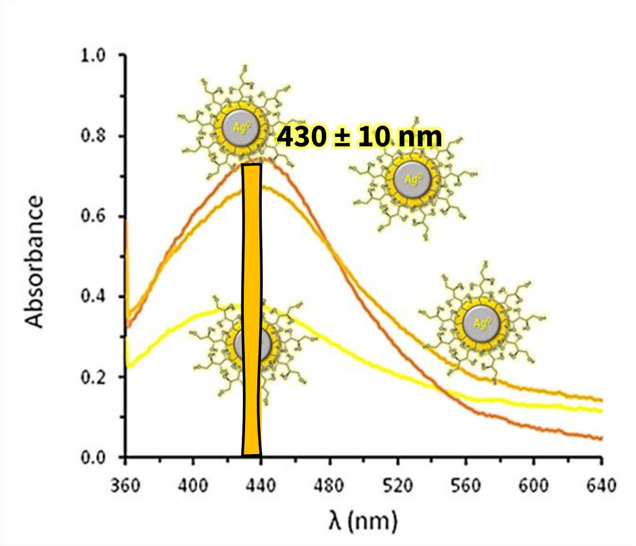
Sugars content evaluation trough AgNPs formation

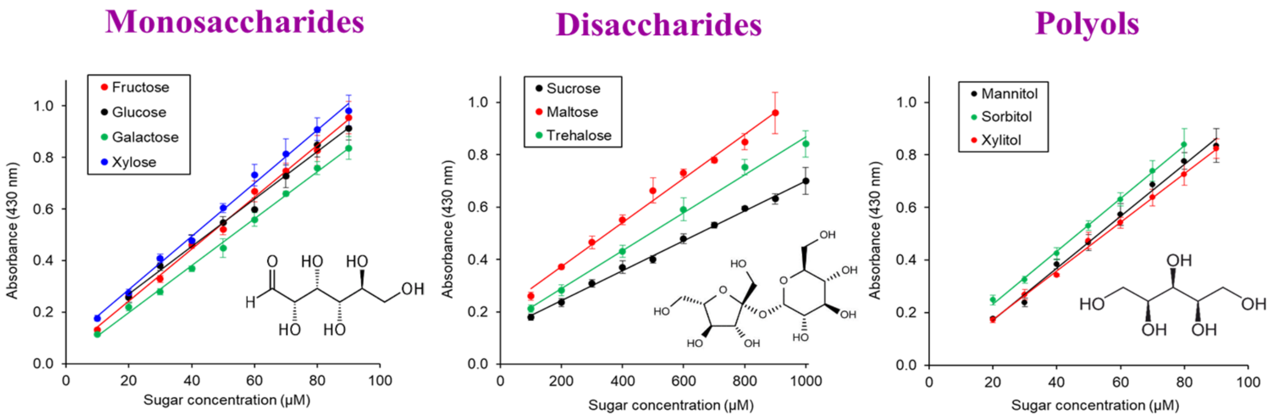

Analytica Chimica Acta 1051 (2019) 129–137
Contents lists available at ScienceDirect
Analytica Chimica Acta
journal homepage: www.elsevier.com/locate/aca

Silver nanoparticles-based plasmonic assay for the determination of sugar content in food matrices

Flavio Della Pelle [a], Annalisa Scroccarello [a], Simona Scarano [b], Dario Compagnone [a, *]







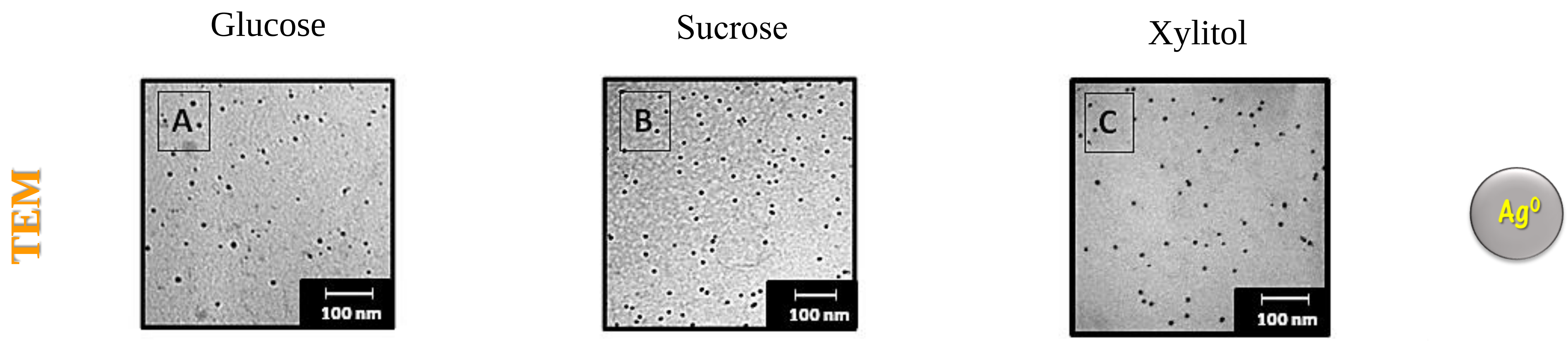
Sample	AgNPs assay (g 100 mL^{-1}, Glu. Eq.)	RSD (%, n = 5)	Ion chromatography (g 100 mL^{-1}, Glu + Fru)	RSD (%, n = 3)	Rel. error (%)
Peach tea	2.98 ± 0.14	4.74	3.13 ± 0.08	2.71	+ 5.0
Black tea	3.56 ± 0.23	6.51	3.05 ± 0.11	3.56	- 14.3
Coconut water	4.72 ± 0.13	2.84	4.93 ± 0.05	0.98	+ 4.4
Gaseous	3.50 ± 0.25	7.23	3.53 ± 0.04	1.21	+ 0.9
Cedrata	9.36 ± 0.27	2.85	8.74 ± 0.78	8.9	- 6.6
Tonic water	6.11 ± 0.07	1.15	5.62 ± 0.12	2.11	- 8.0
Apple 1	1.67 ± 0.02	1.12	1.50 ± 0.02	1.11	- 10.2
Apple 2	1.14 ± 0.04	3.41	1.14 ± 0.02	1.78	0.0
Apple 3	3.27 ± 0.04	1.30	3.12 ± 0.10	3.10	- 4.6
Apple 4	2.43 ± 0.23	9.42	2.67 ± 0.11	4.10	+ 9.9
Apple 5	2.43 ± 0.02	0.74	2.31 ± 0.9	3.80	- 5.0

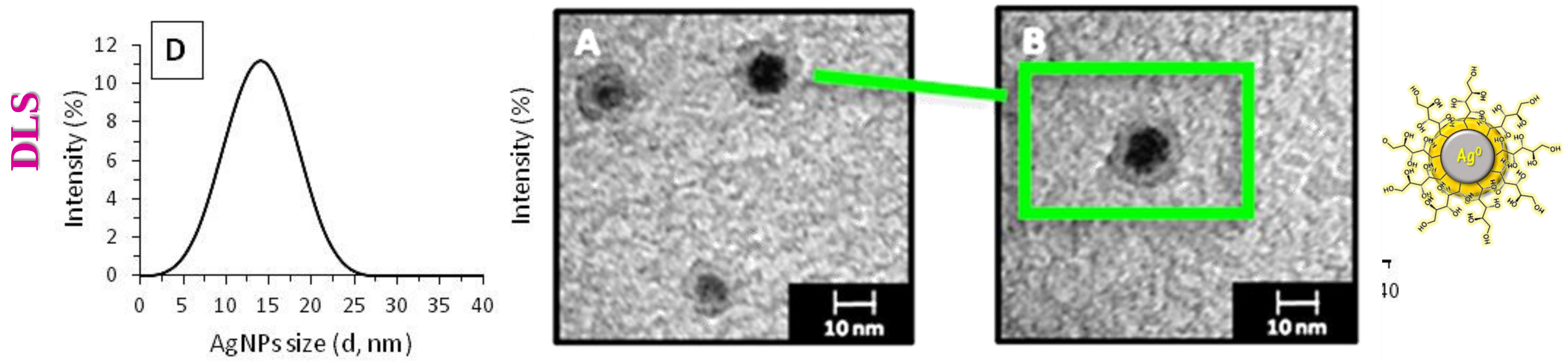
$R^2 \geq 0.991$
Monosaccharides and polyols LOD= 8.7 ± 0.4 µM
Disaccharides average LOD= 120 ± 0.1 µM
RSD≤ 8%

Recovery: 86-118%

Metal nanoparticles formation

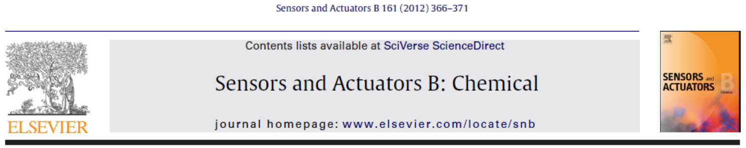
AgNPs Morphological study





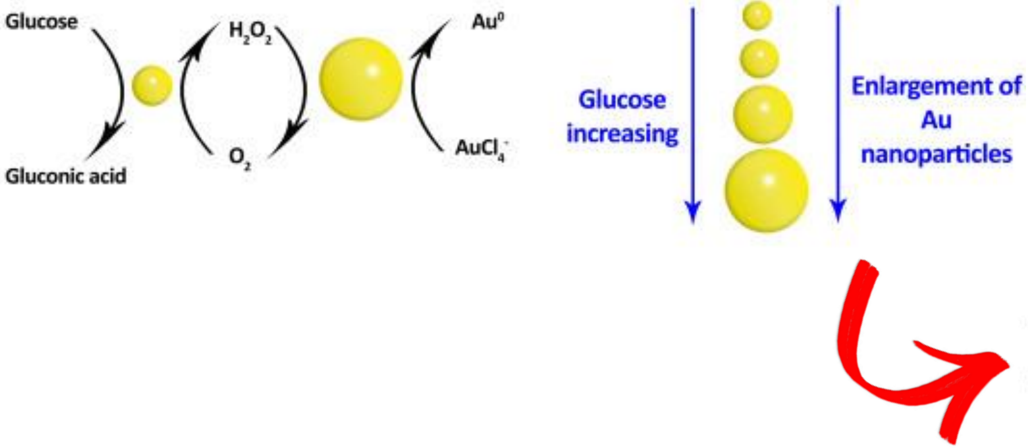
Metal nanoparticles formation

Sugars content evaluation trough AuNPs formation

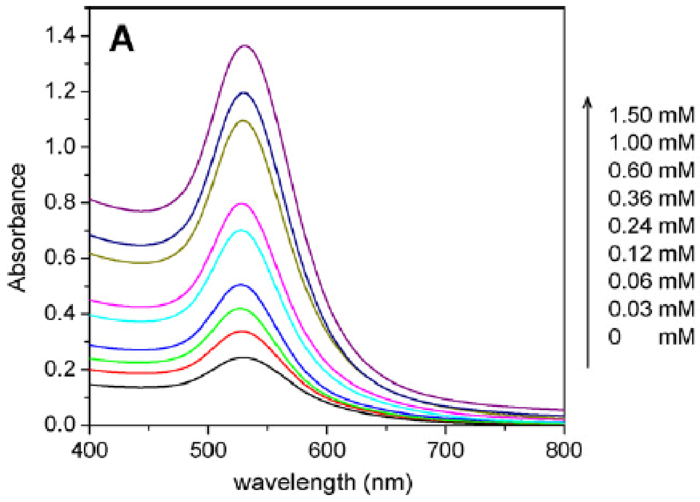

Sensors and Actuators B 161 (2012) 366–371
Contents lists available at SciVerse ScienceDirect
Sensors and Actuators B: Chemical
journal homepage: www.elsevier.com/locate/snb

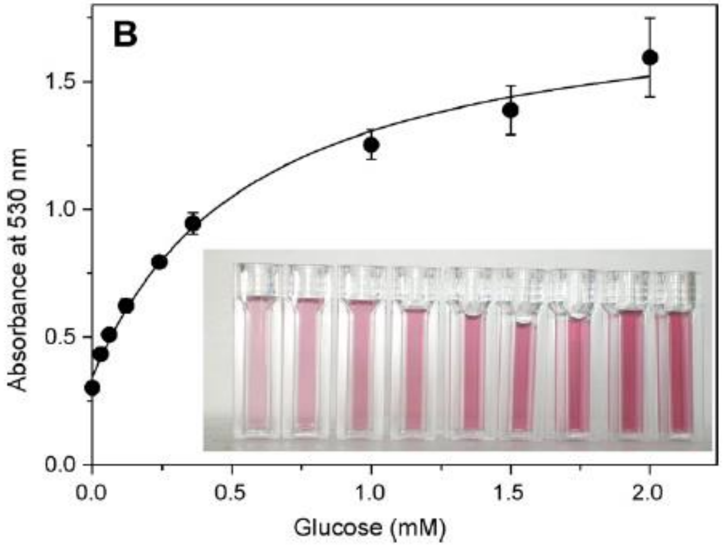
Colorimetric detection of sugars based on gold nanoparticle formation

Gerardo Palazzo[a], Laura Facchini[a], Antonia Mallardi[b,*]

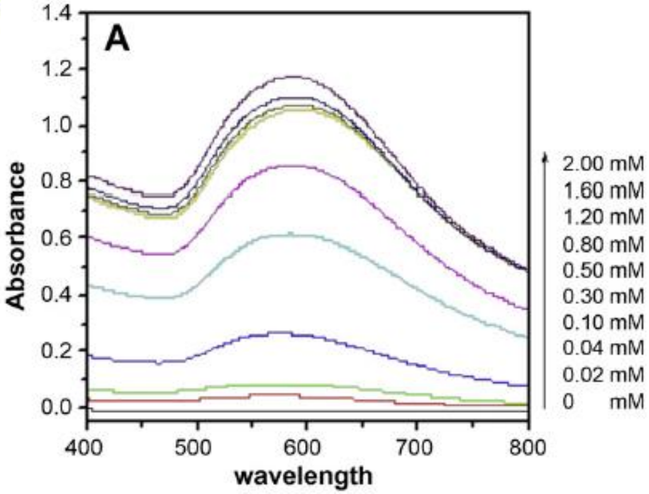


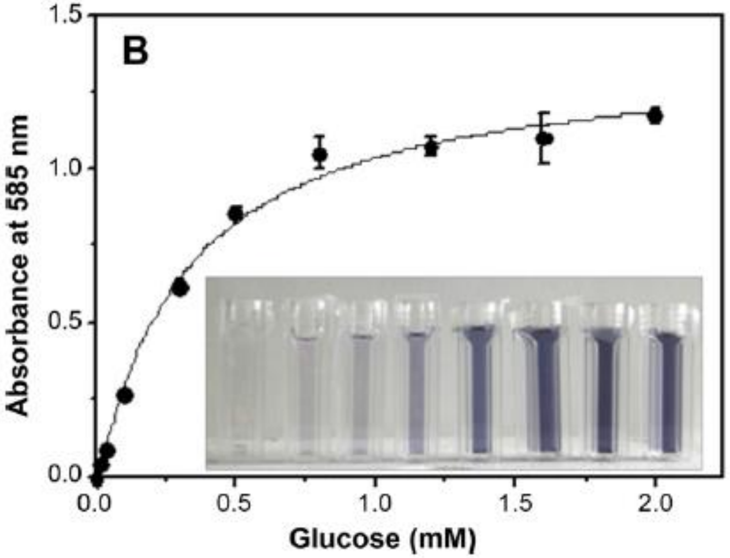
Glucose sensing



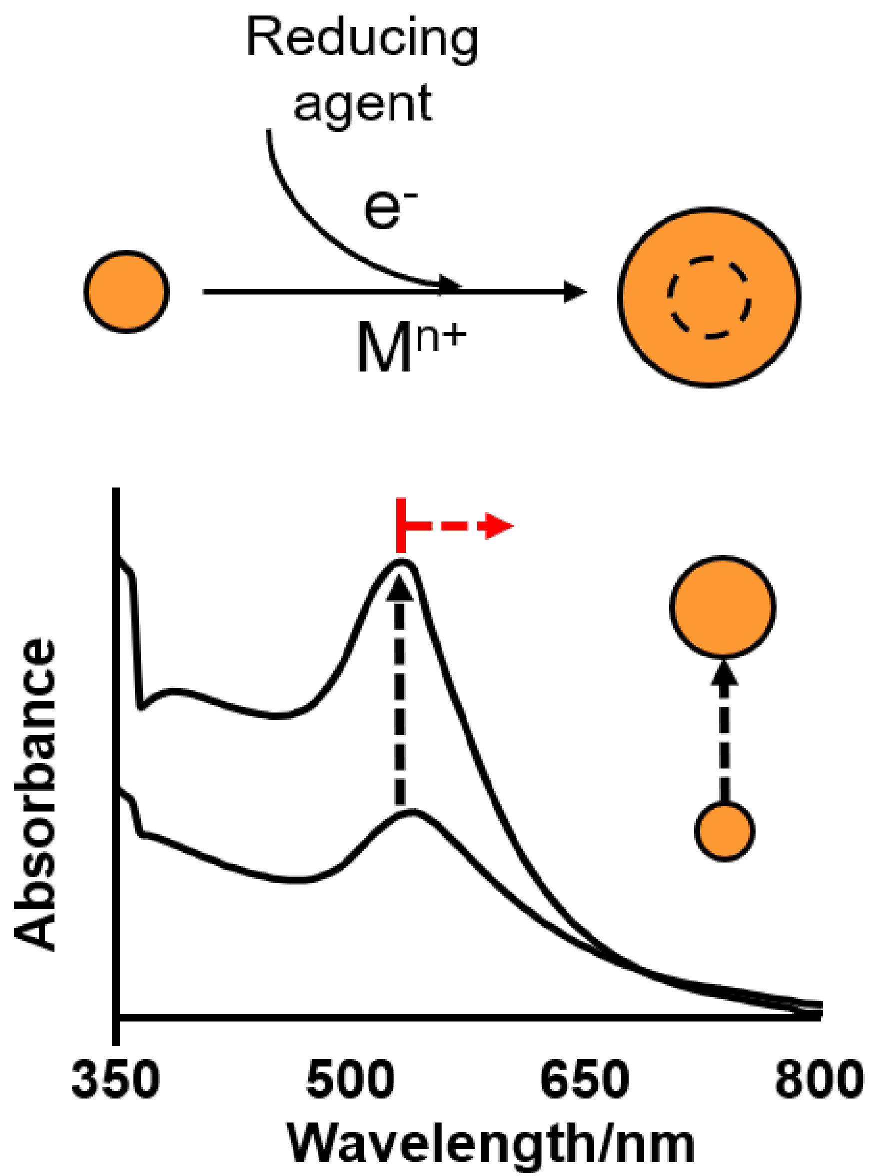


Glucose biosensing





Metal nanoparticle-based seed-growth strategies



Metal nanoparticles growth

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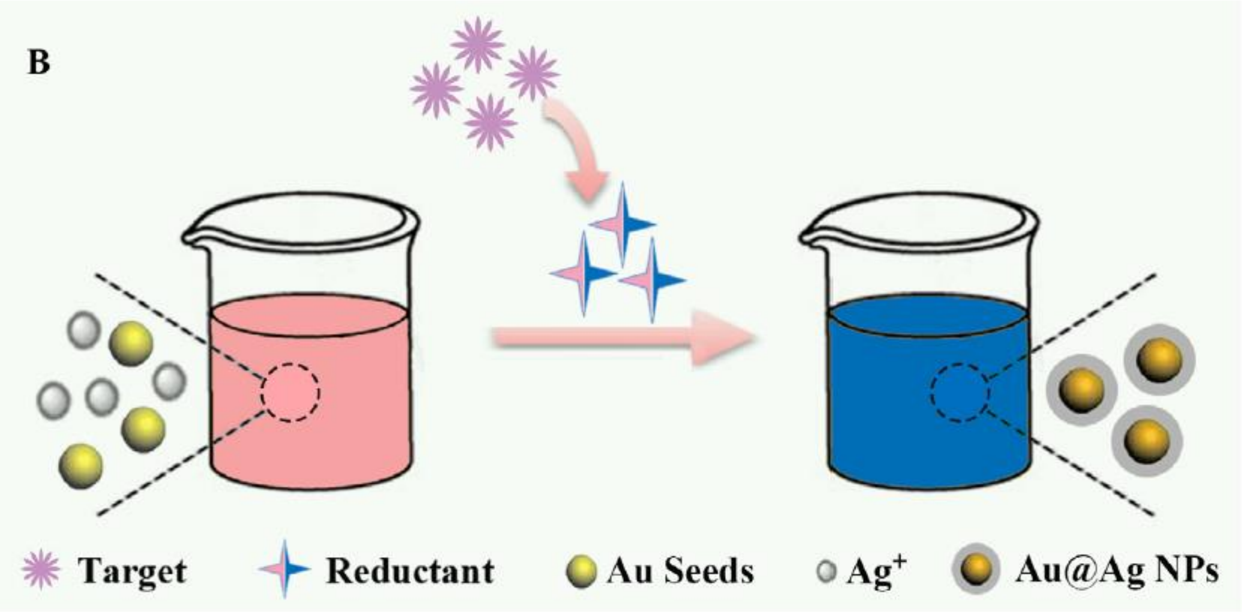
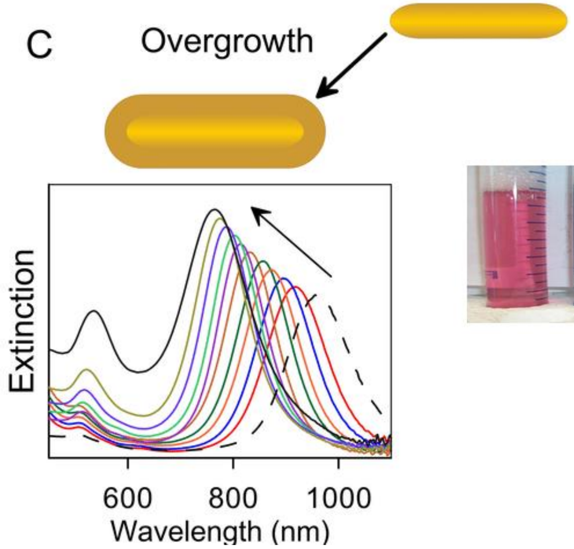
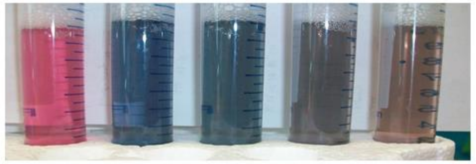
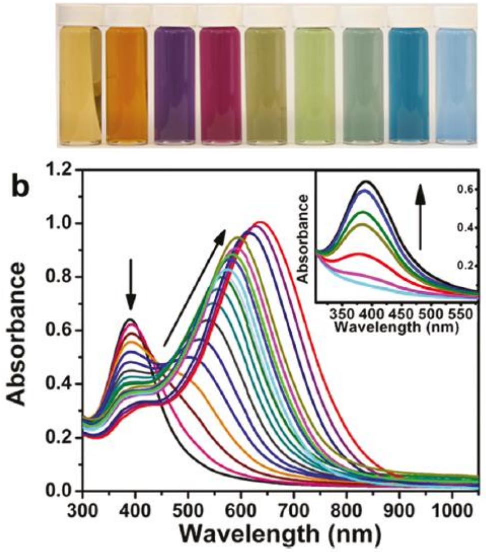
Main strategy

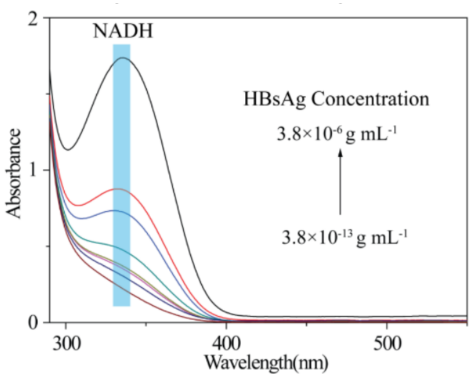


Analytical signal









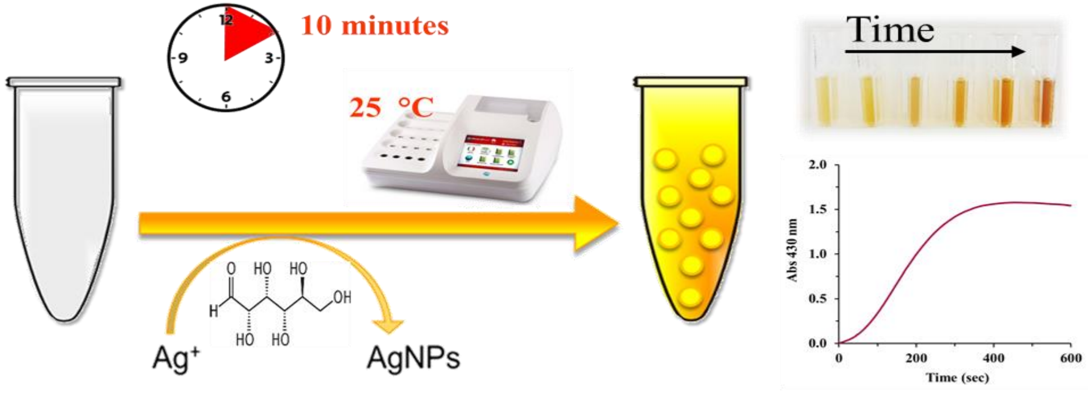
Metal nanoparticles growth

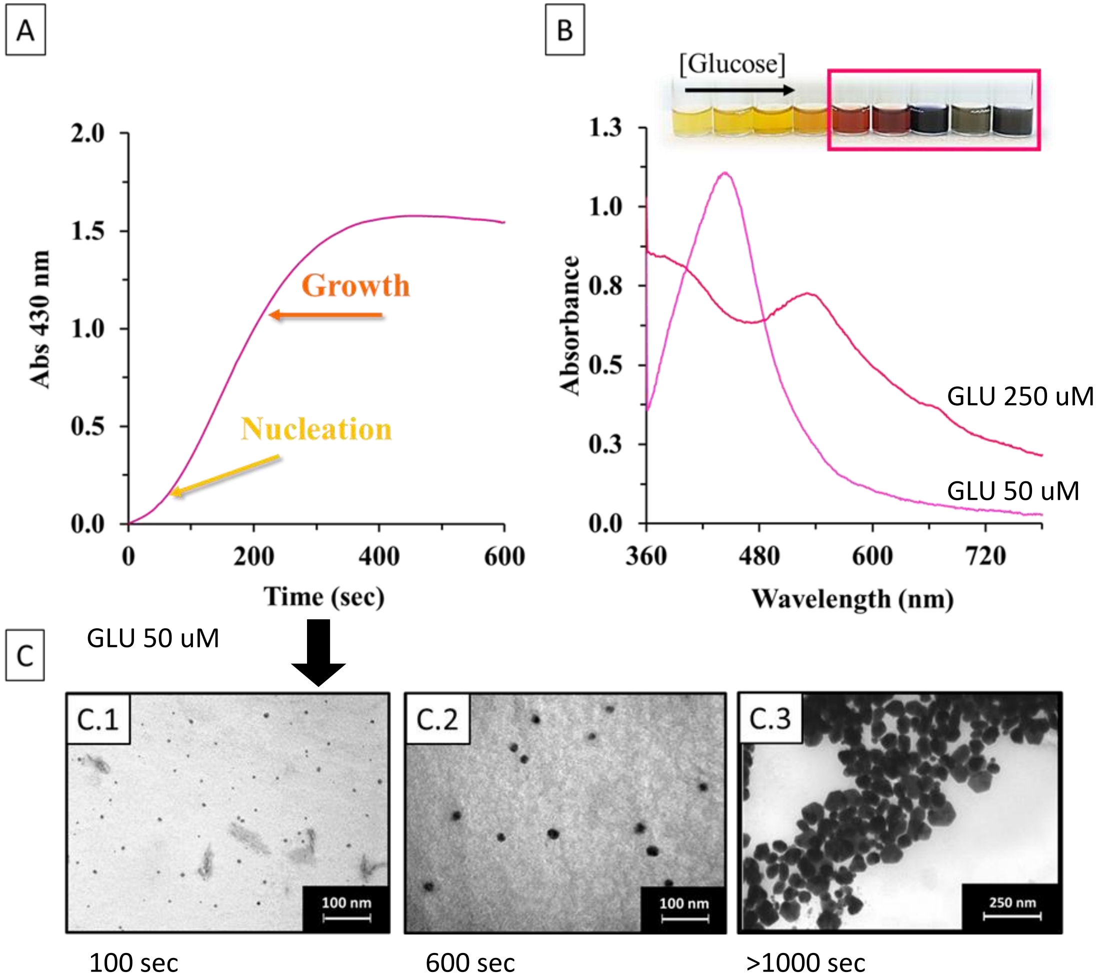
Reducing sugars monitoring trough AgNPs growth

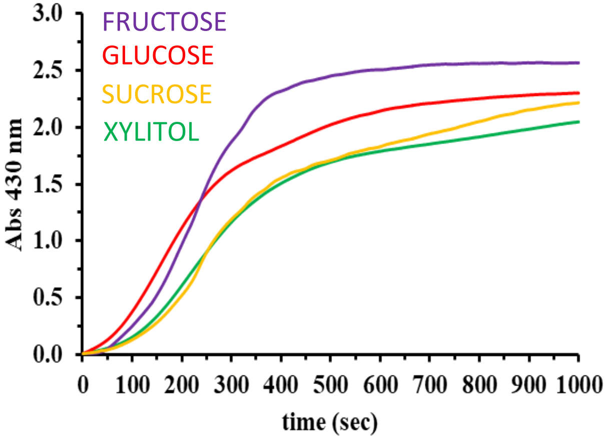
Studies on Silver Nanoparticles Production Mediated by Sugars

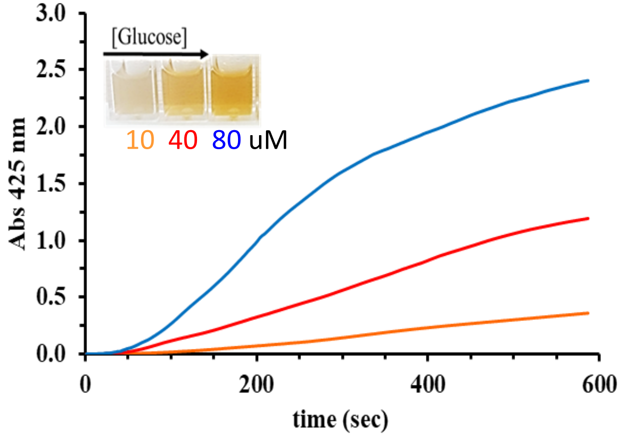
Annalisa Scroccarello, Flavio Della Pelle, Simona Scarano and Dario Compagnone

G. Di Francia et al. (eds.), *Sensors and Microsystems*, Lecture Notes in Electrical Engineering 629, https://doi.org/10.1007/978-3-030-37558-4_5





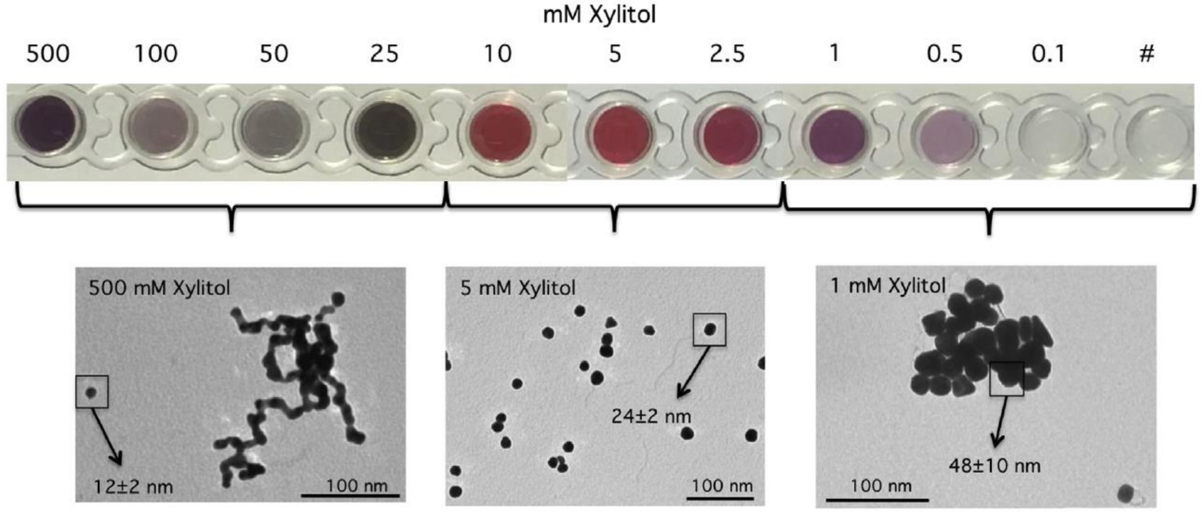




Metal nanoparticles growth

Xylitol monitoring trough AuNPs growth

Seed formation and growth phenomena study



Analytica Chimica Acta xxx (2017) 1–8
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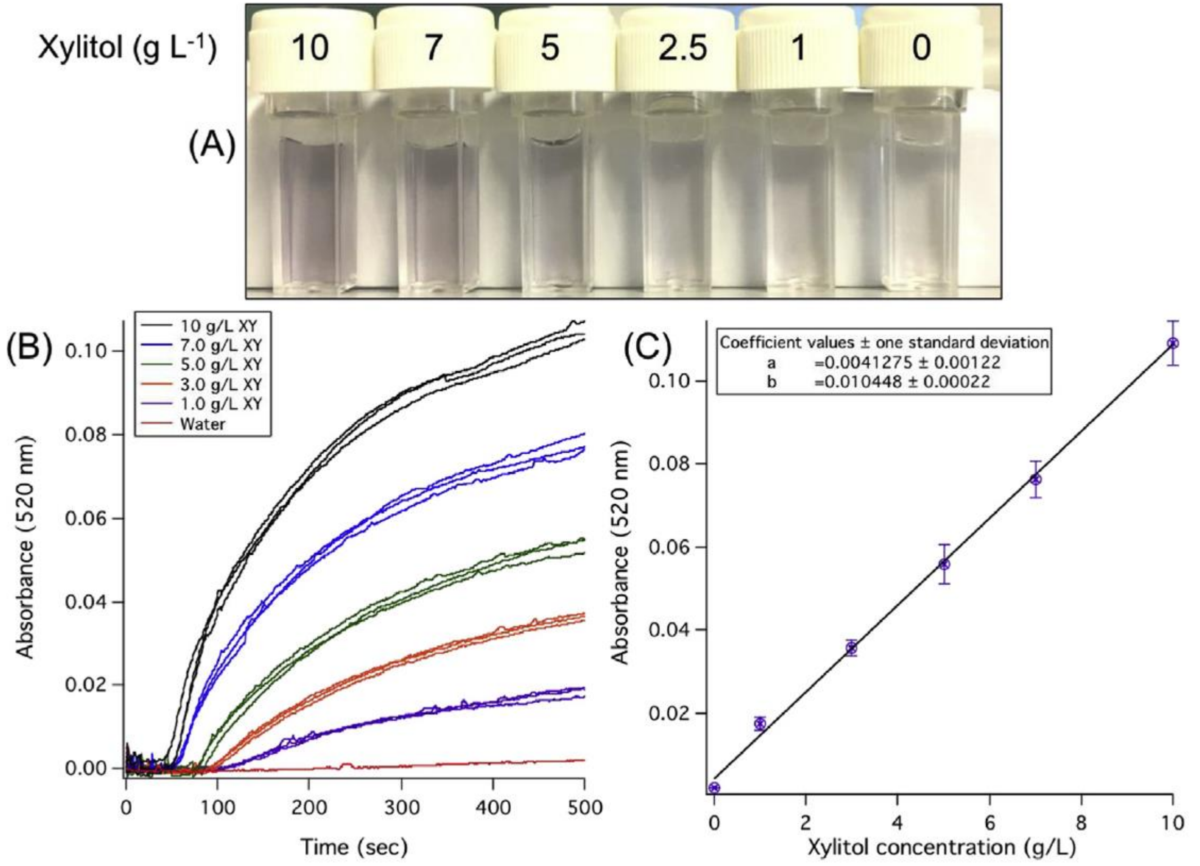
The early nucleation stage of gold nanoparticles formation in solution as powerful tool for the colorimetric determination of reducing agents: The case of xylitol and total polyols in oral fluid

S. Scarano*, E. Pascale, M. Minunni

Dose-response kinetic and curve



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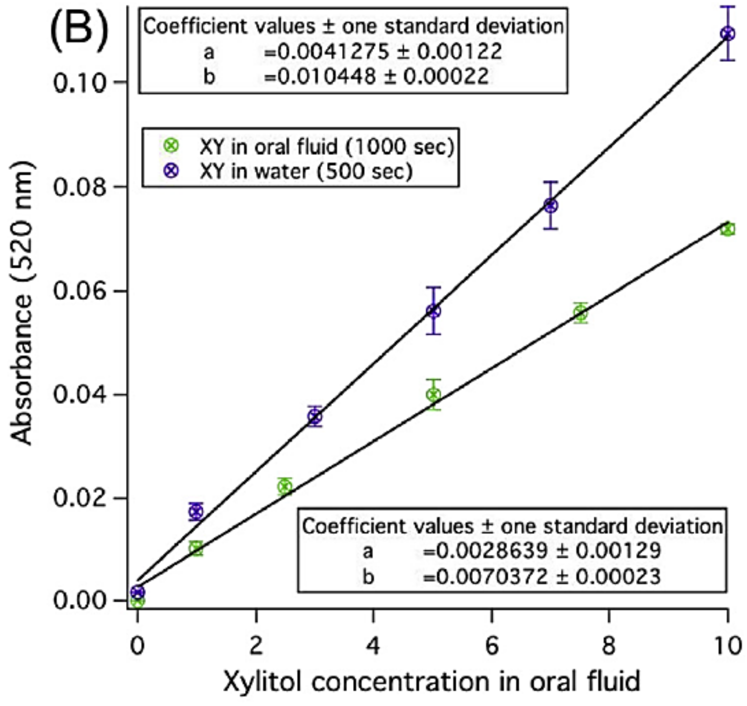
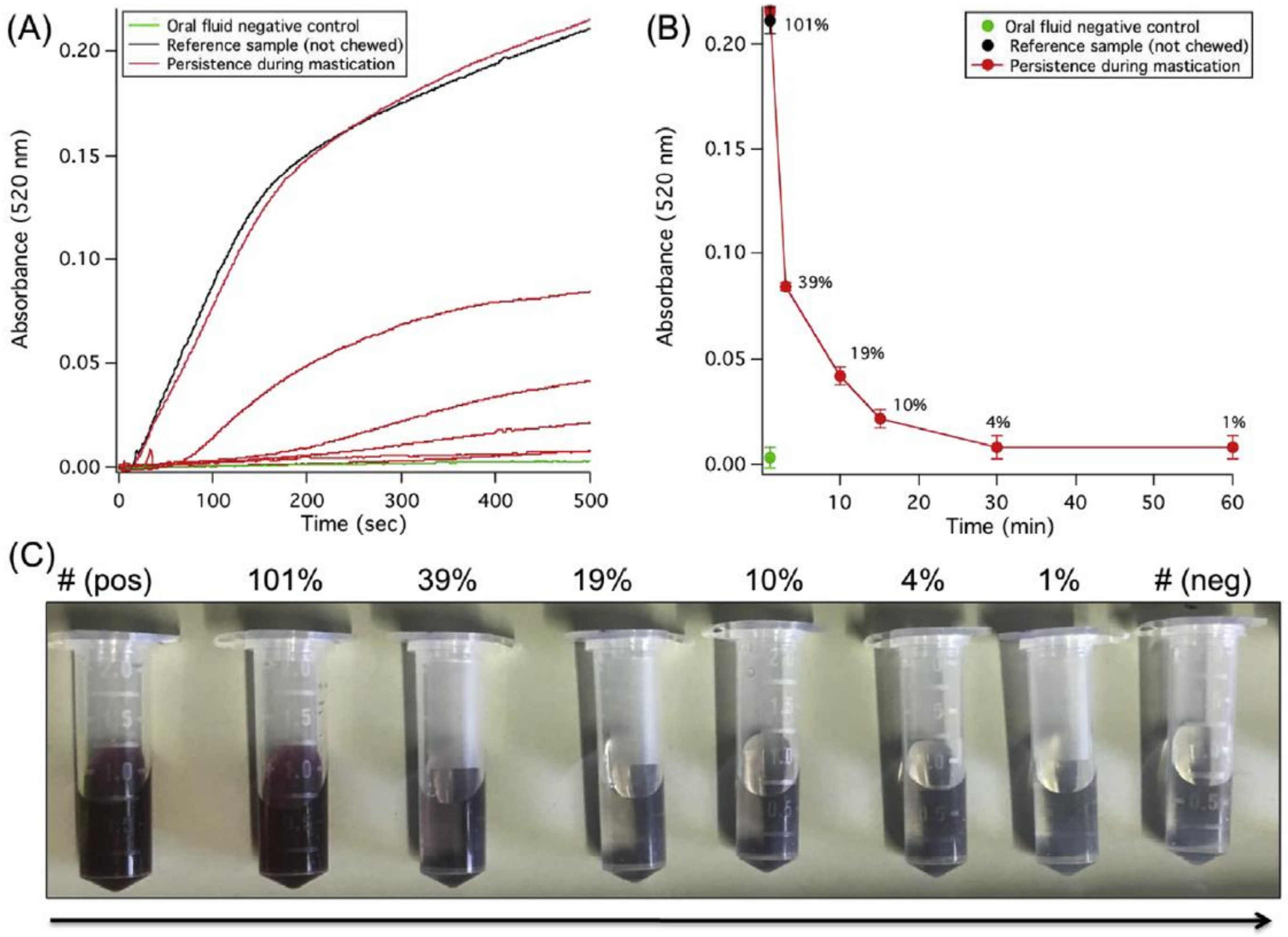
Xylitol monitoring in human saliva trough AuNPs growth

Recovery study

Methods evalutaion for sample analysis



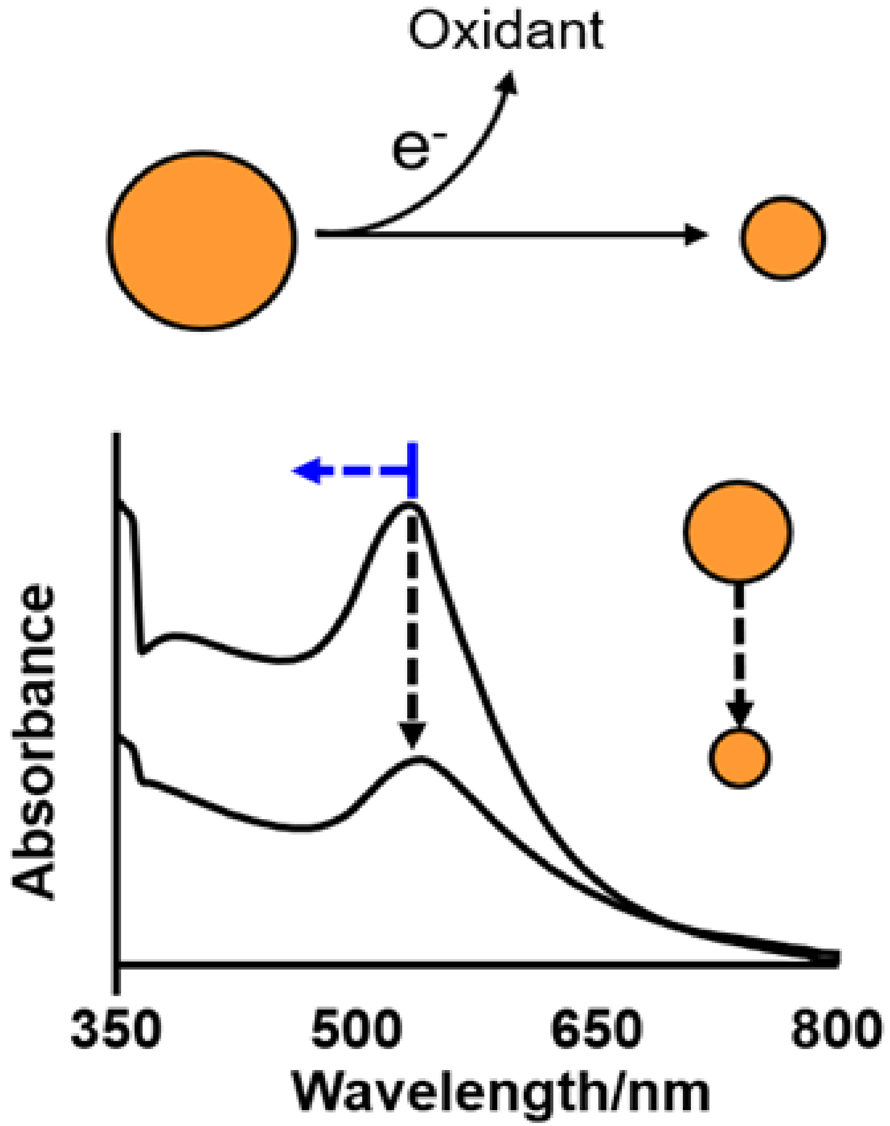
Xylitol montoring along 1 hours of chewin-gum mastication



Xylitol decay

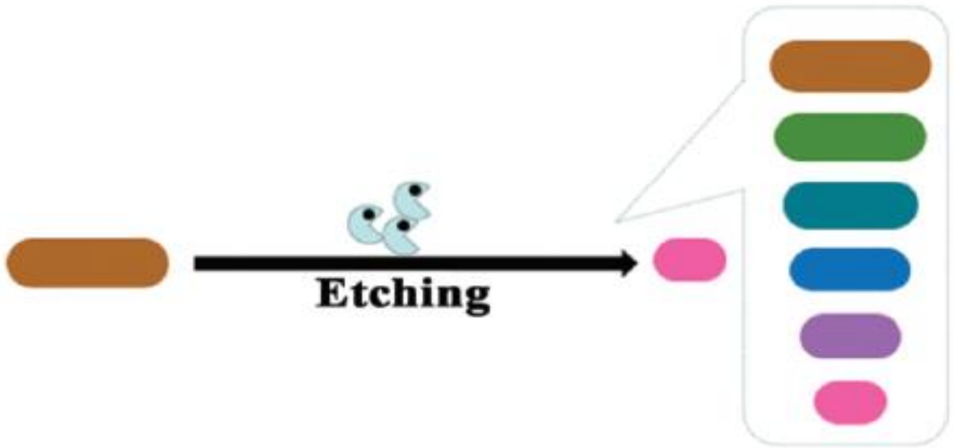
Time (min)

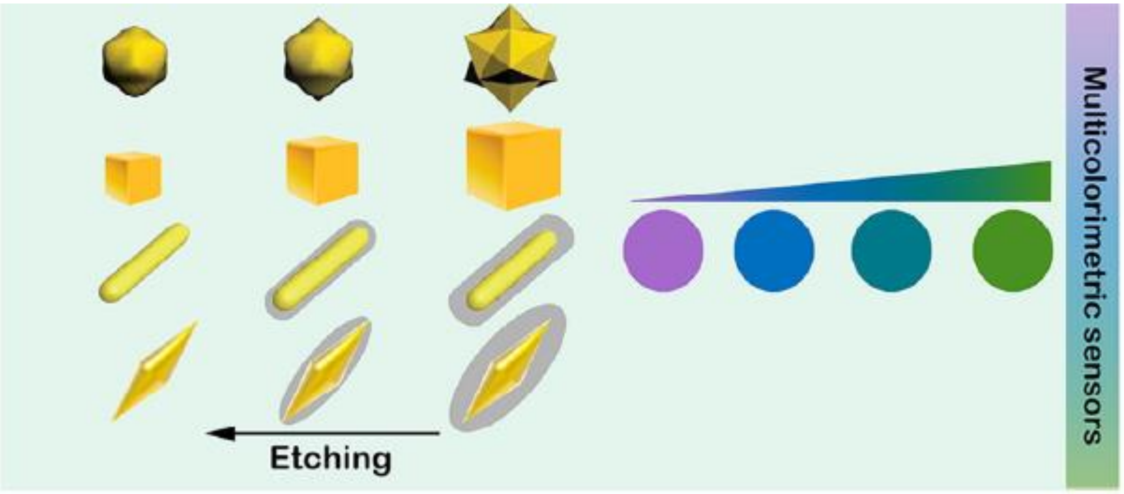
Metal nanoparticle etching



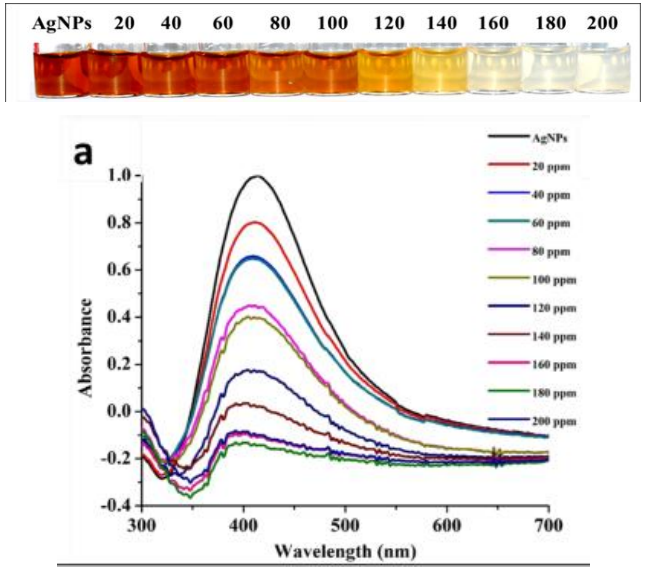
Metal nanoparticles etching

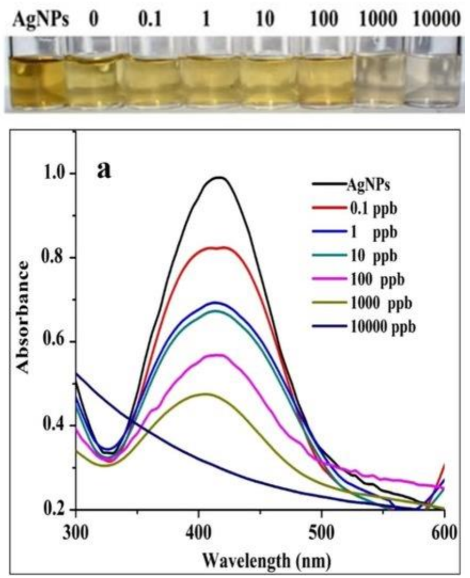
Main strategy

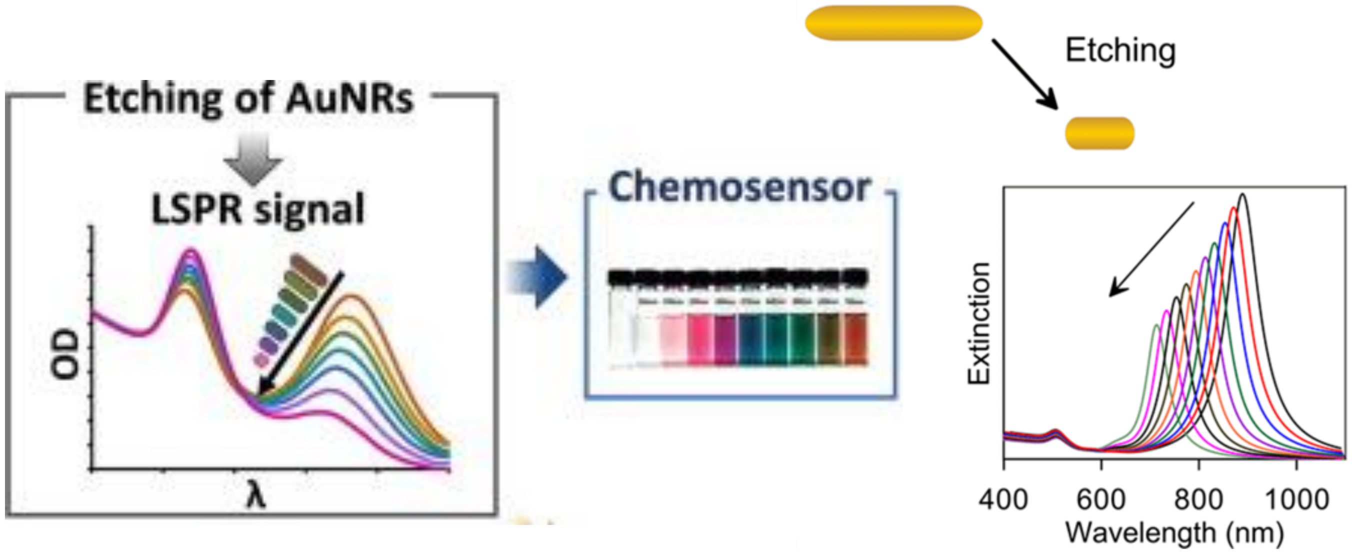




Analytical signal

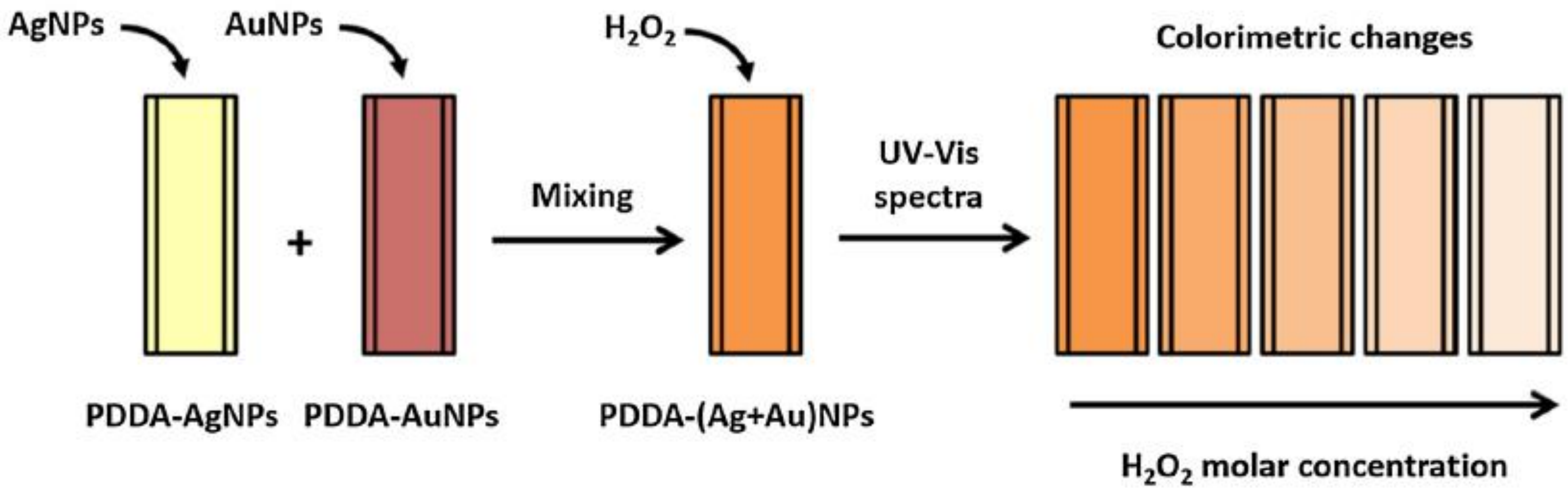


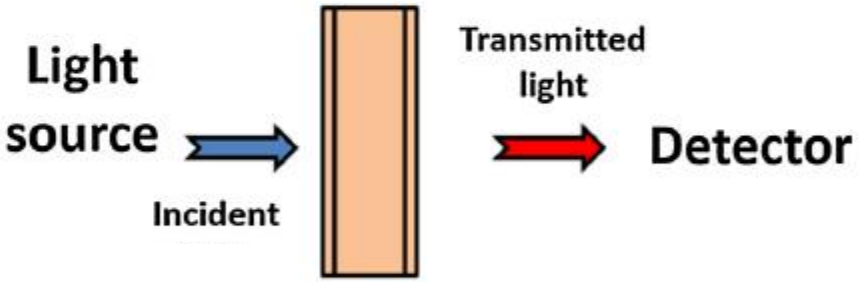


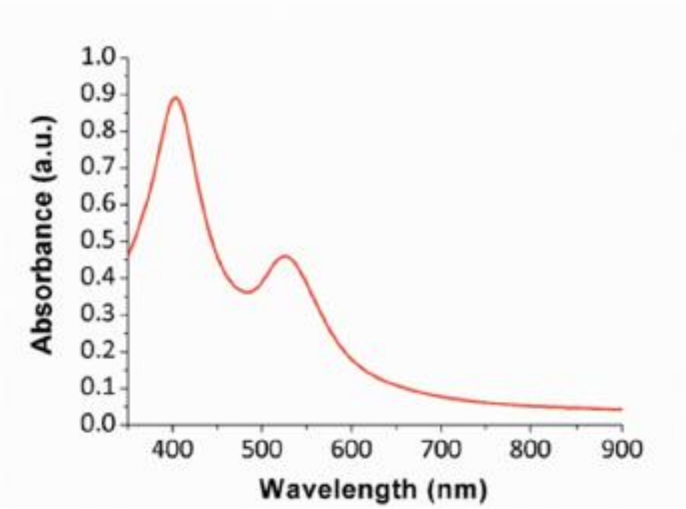


Metal nanoparticles etching

H_2O_2 determination trough MNPs etching







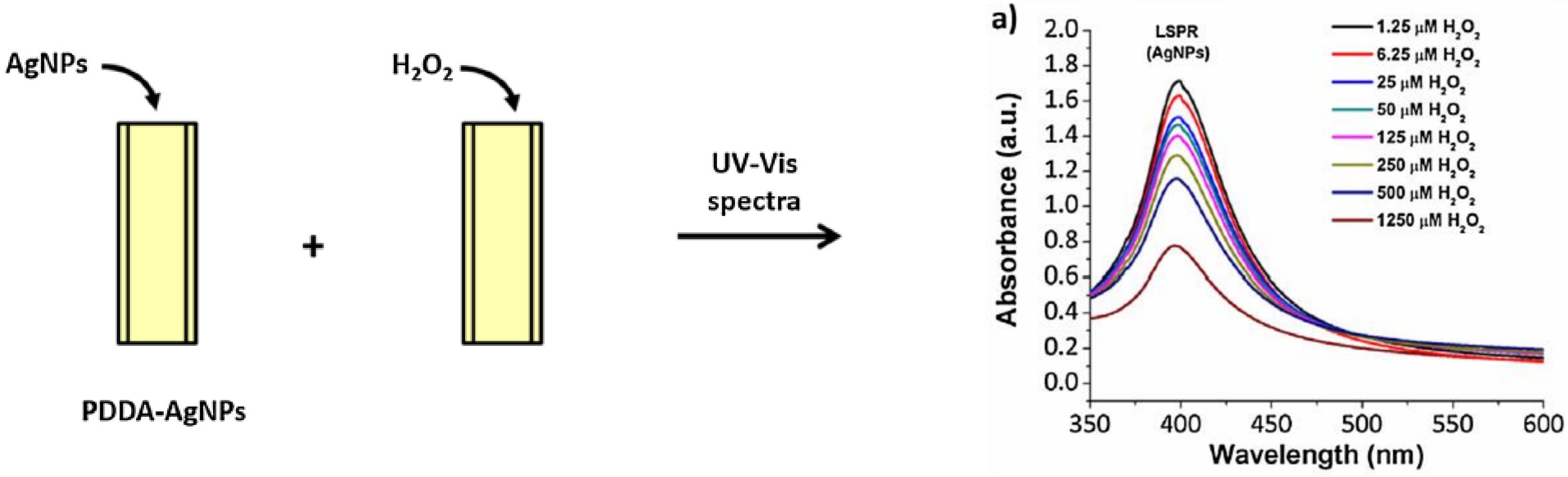
Sensors and Actuators B 251 (2017) 624–631
Contents lists available at ScienceDirect
Sensors and Actuators B: Chemical
journal homepage: www.elsevier.com/locate/snb

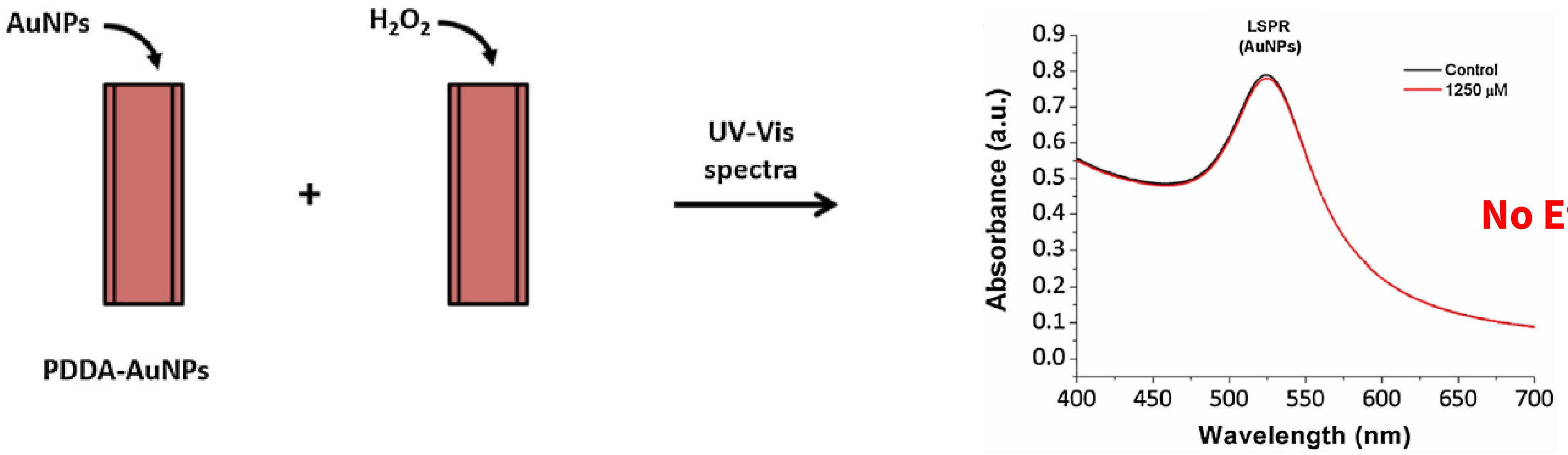
A self-referenced optical colorimetric sensor based on silver and gold nanoparticles for quantitative determination of hydrogen peroxide

Pedro J. Rivero[a,*], Elia Ibañez[b], Javier Goicoechea[b], Aitor Urrutia[b], Ignacio R. Matias[c], Francisco J. Arregui[b]

Metal nanoparticles etching

Etching phenomena study

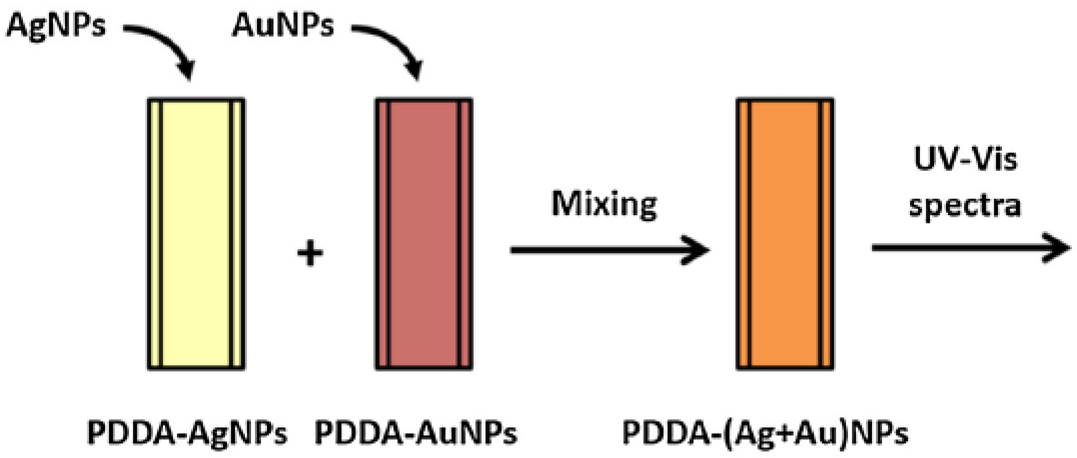


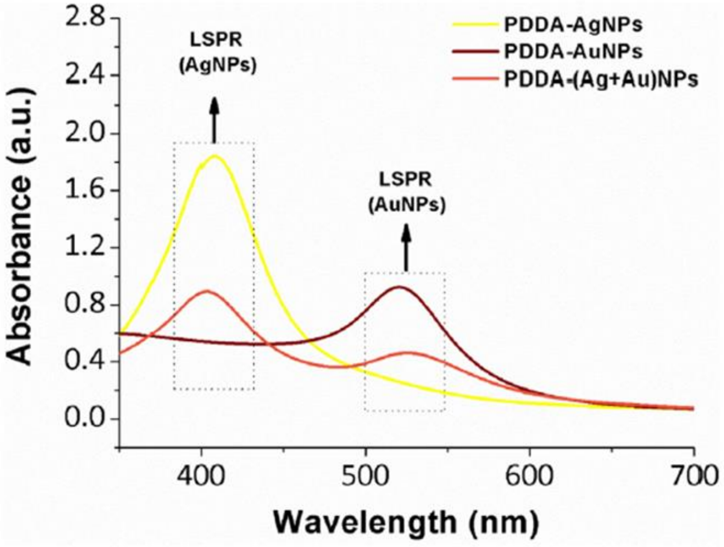


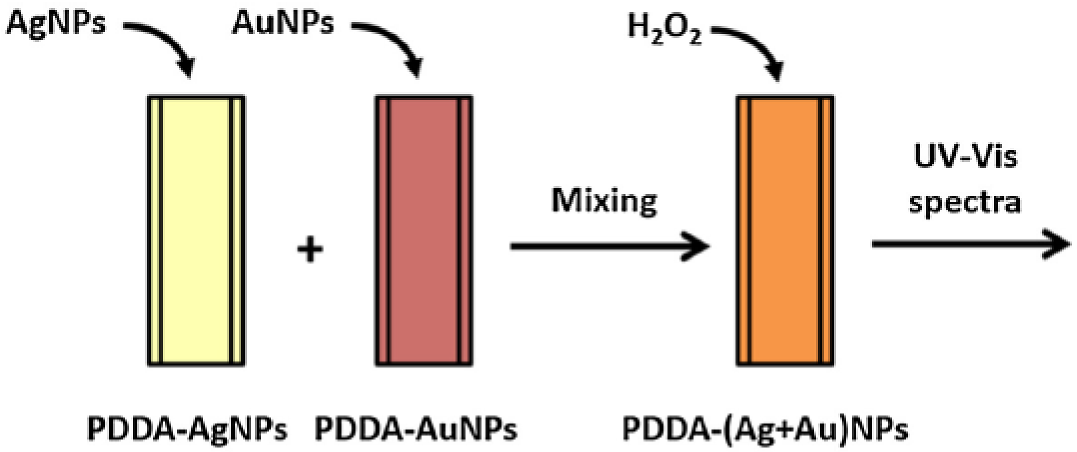
No Etching phenomena

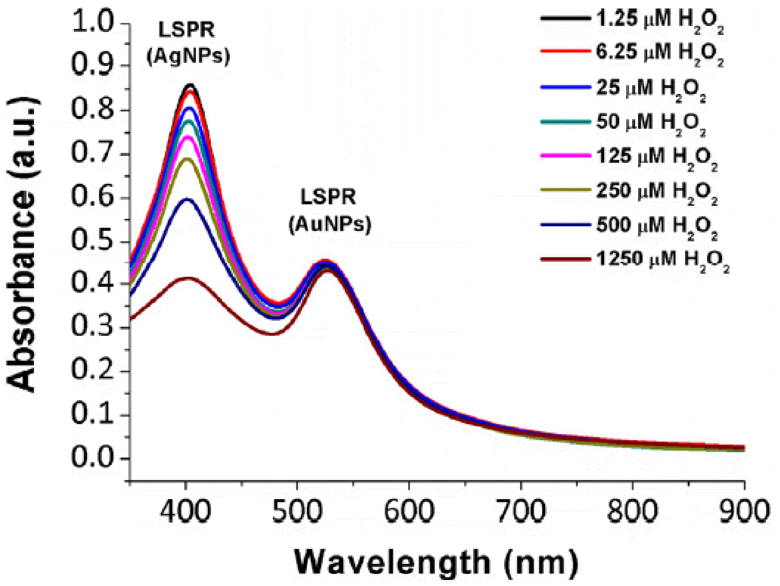
Metal nanoparticles etching

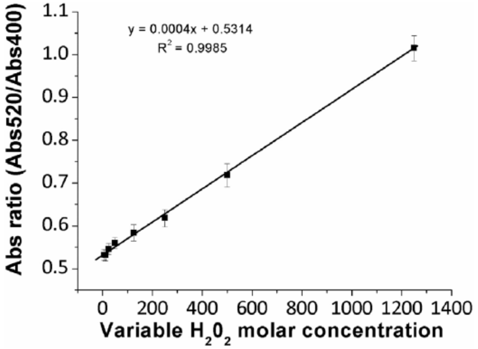
Etching phenomena study. H_2O_2 determination

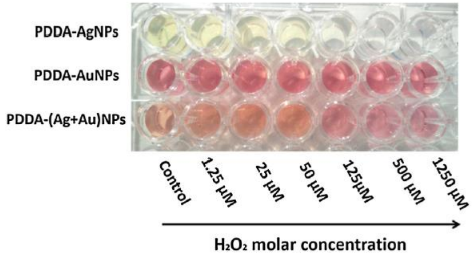










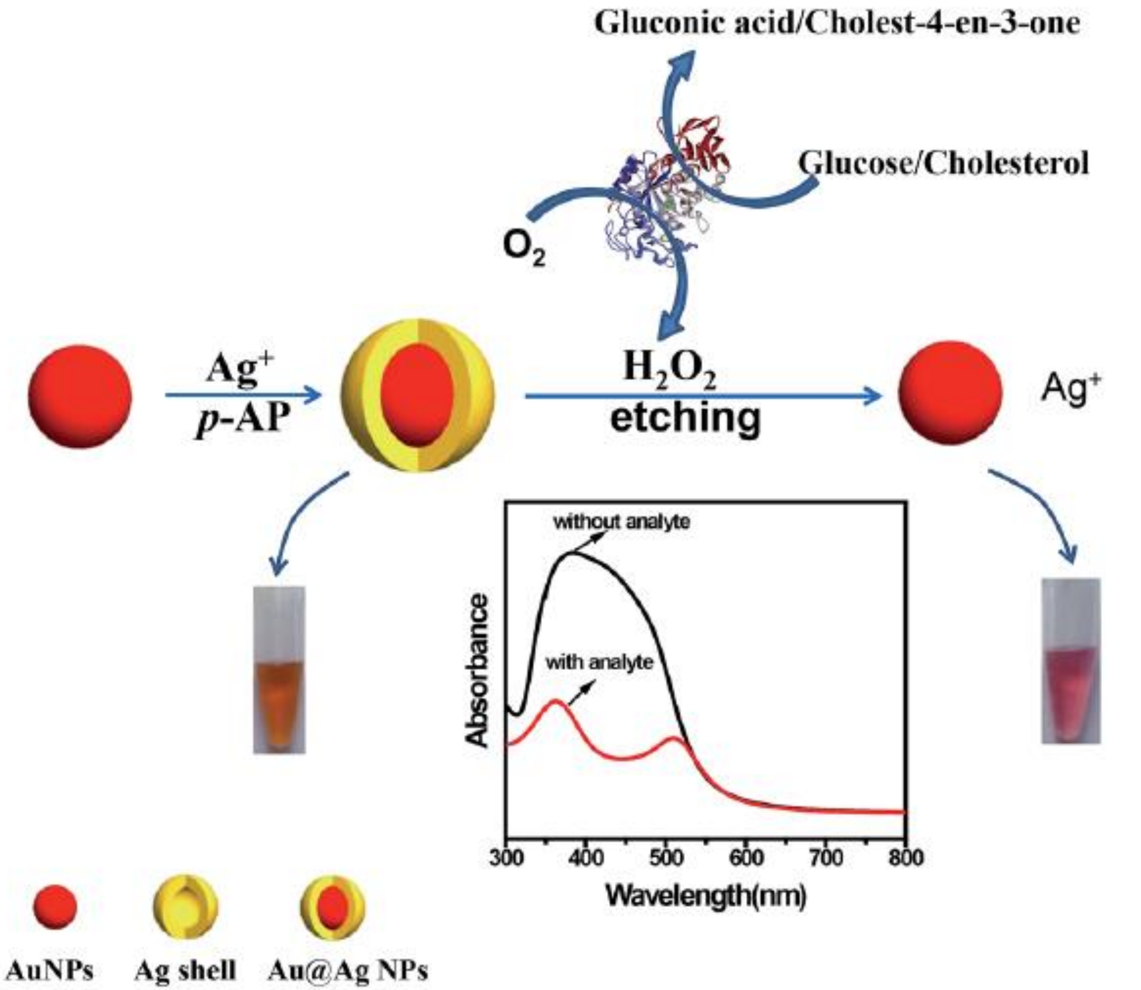


Metal nanoparticles etching

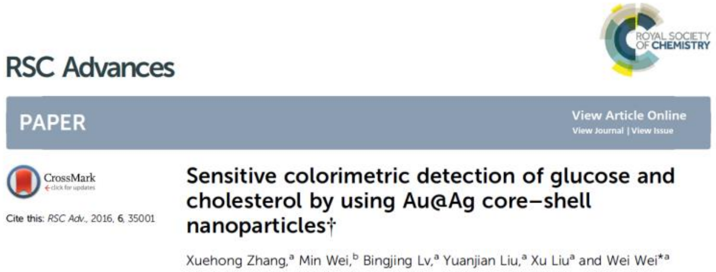
Glucose and cholesterol evaluation trough MNPs etching

$$\text{Glucose} + O_2 + H_2O \xrightarrow{\text{GOx}} \text{gluconic acid} + H_2O_2$$

$$\text{Cholesterol} + O_2 + H_2O \xrightarrow{\text{ChOx}} \text{cholest-4-en-3-one} + H_2O_2$$



Scheme 1 Schematic illustration of the formation of Au@Ag NPs and its application for the colorimetric detection of H_2O_2 and glucose/cholesterol.


RSC Advances

PAPER

View Article Online
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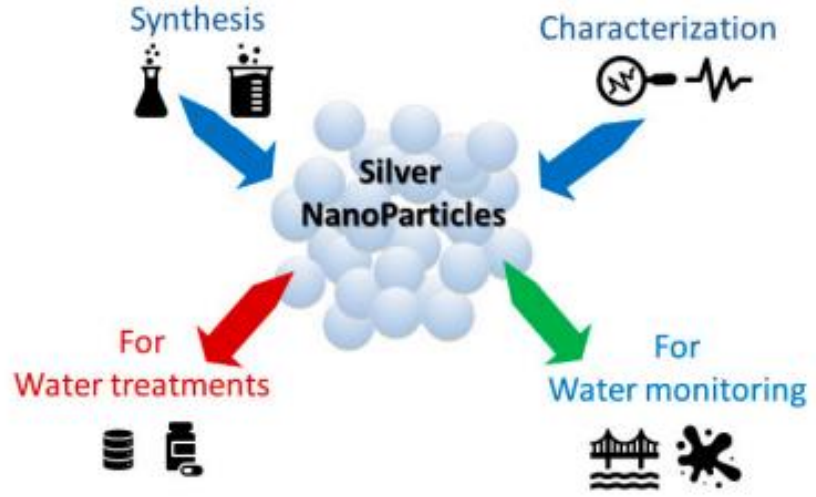
Cite this: RSC Adv., 2016, 6, 35001

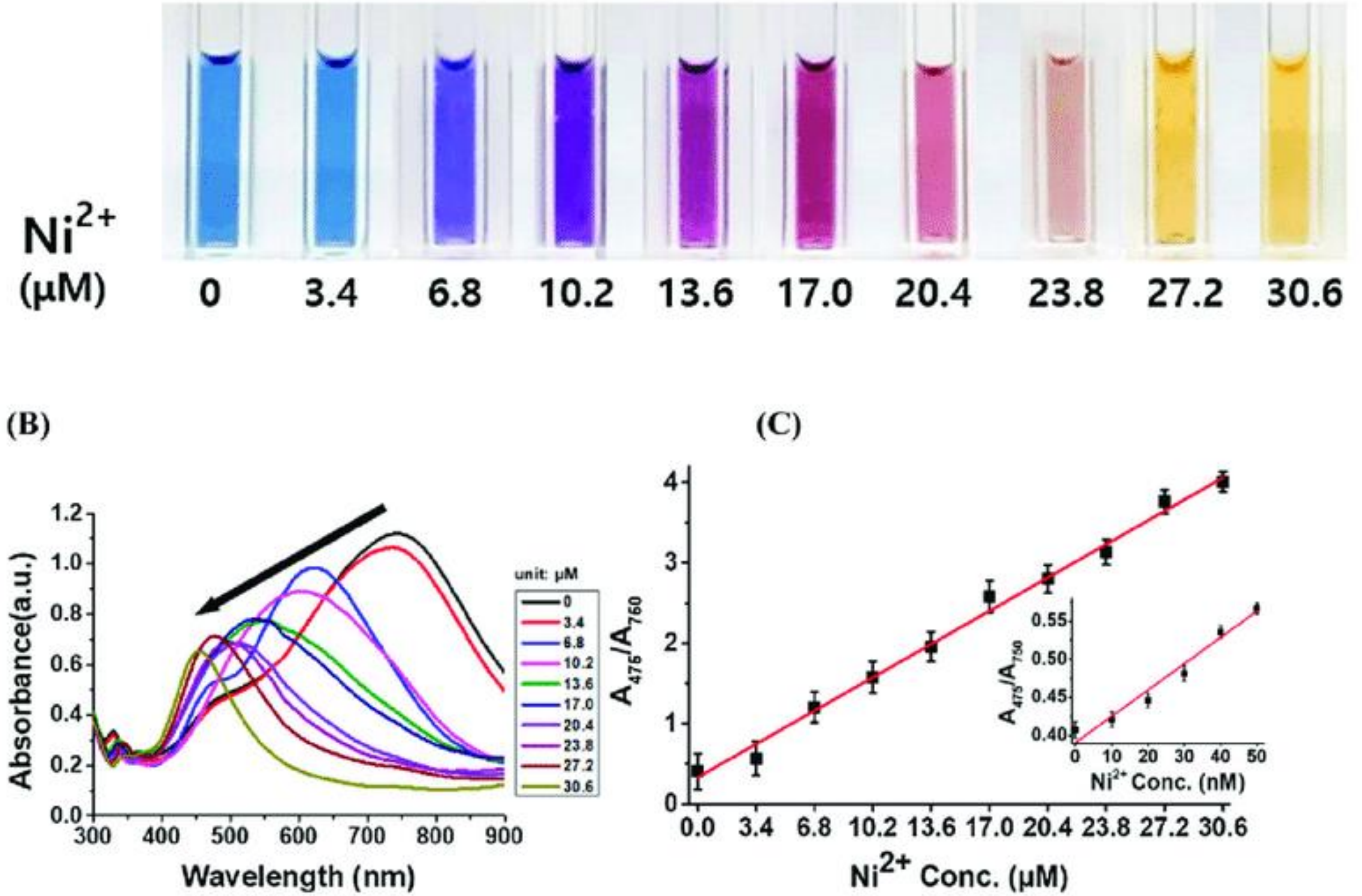
Sensitive colorimetric detection of glucose and cholesterol by using Au@Ag core–shell nanoparticles†

Xuehong Zhang,[a] Min Wei,[b] Bingjing Lv,[a] Yuanjian Liu,[a] Xu Liu[a] and Wei Wei[*a]

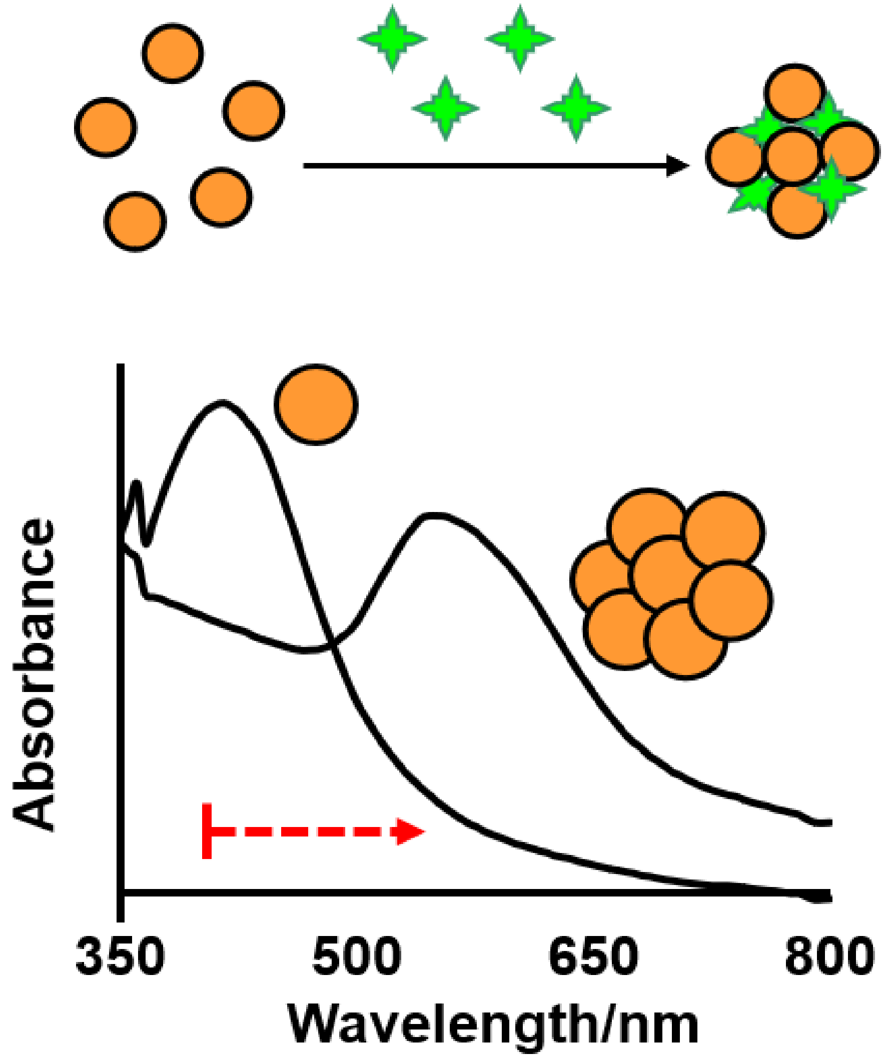
Metal nanoparticles etching

Nickel determination



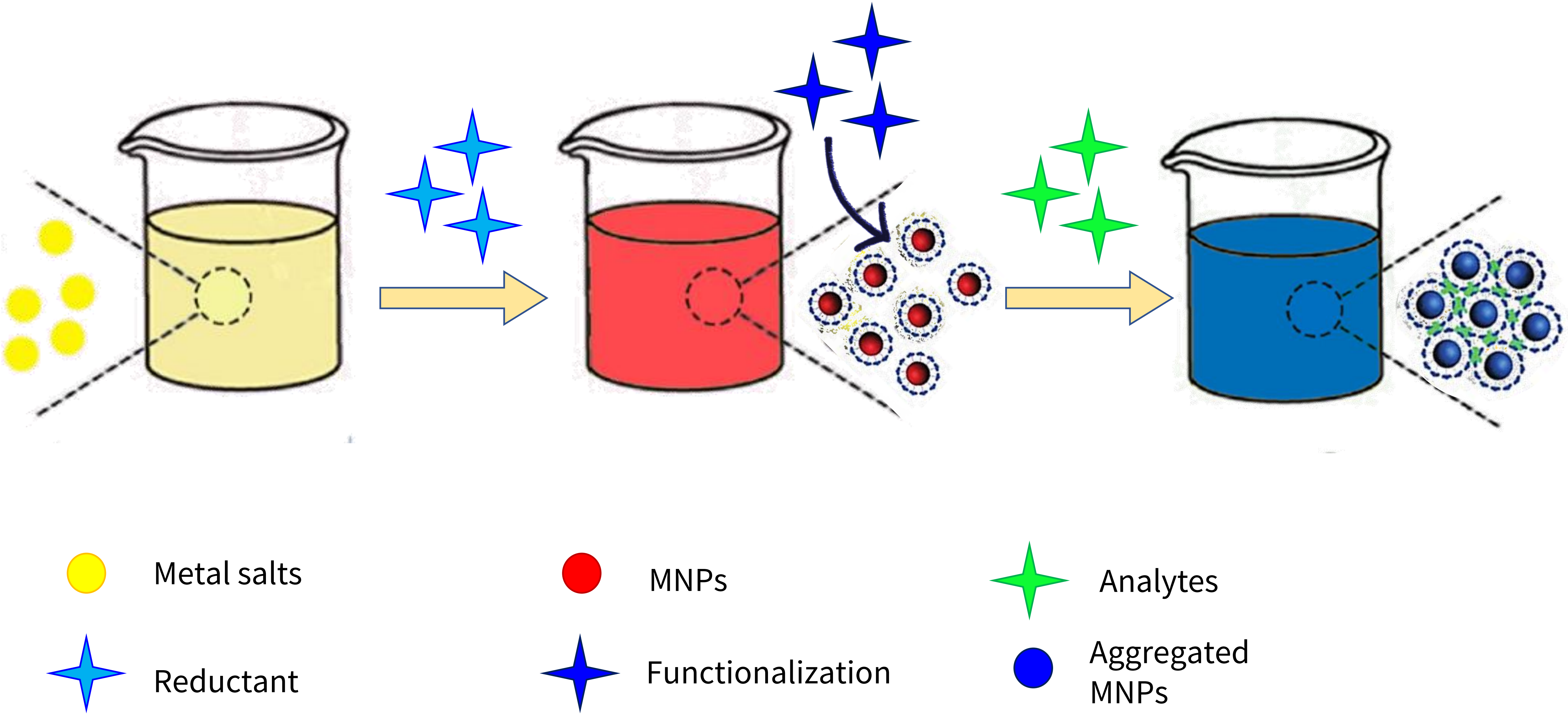


Metal nanoparticle aggregation



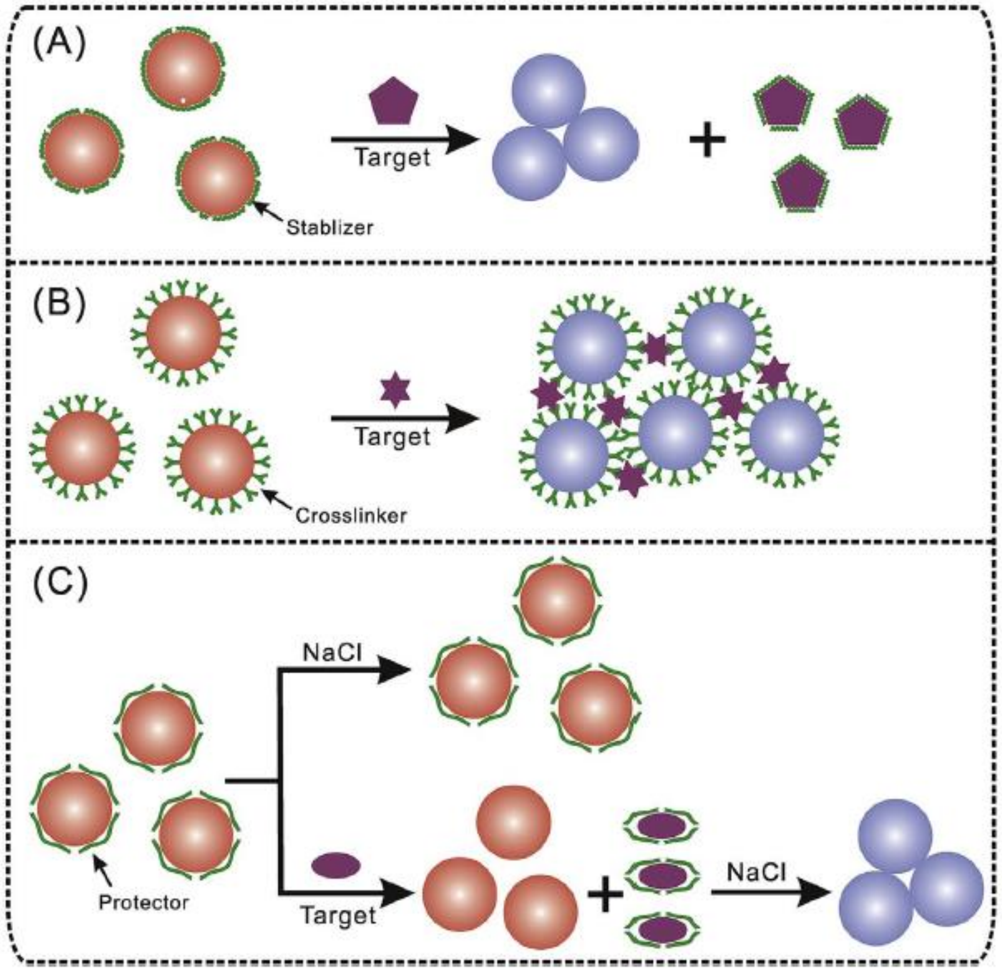
Metal nanoparticles aggregation

Main strategy

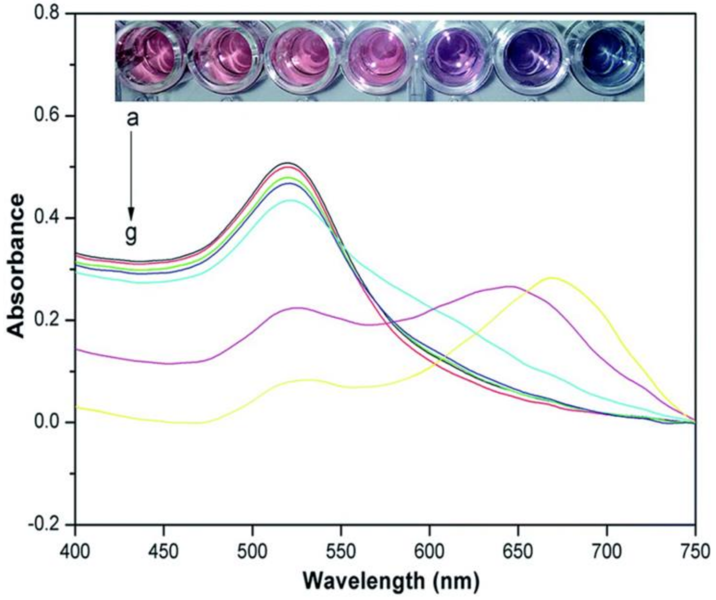


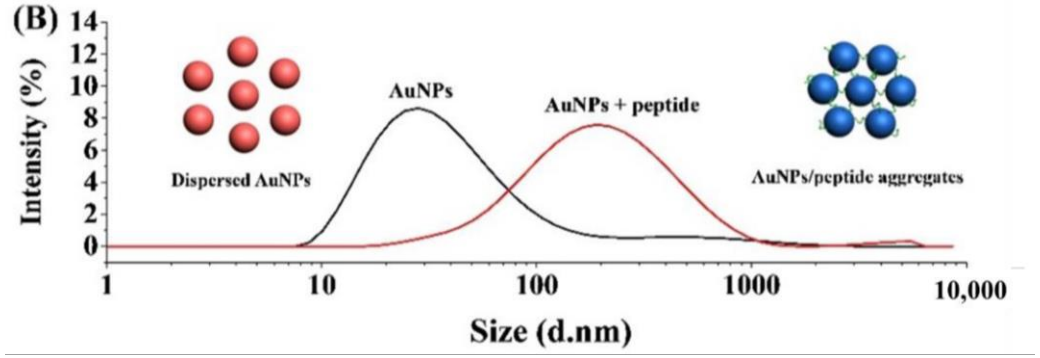
Metal nanoparticles aggregation

Main strategy



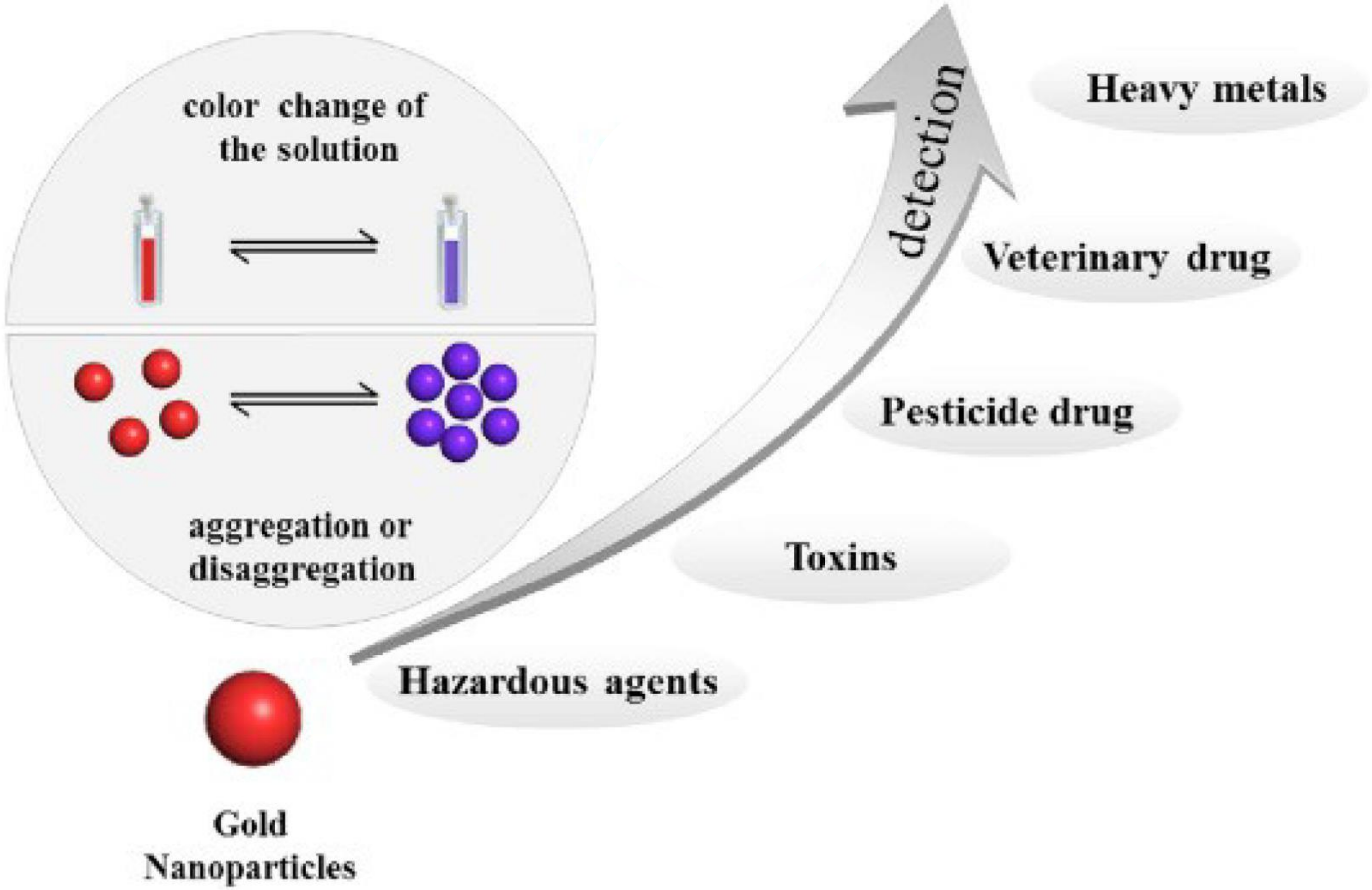
Analytical signal





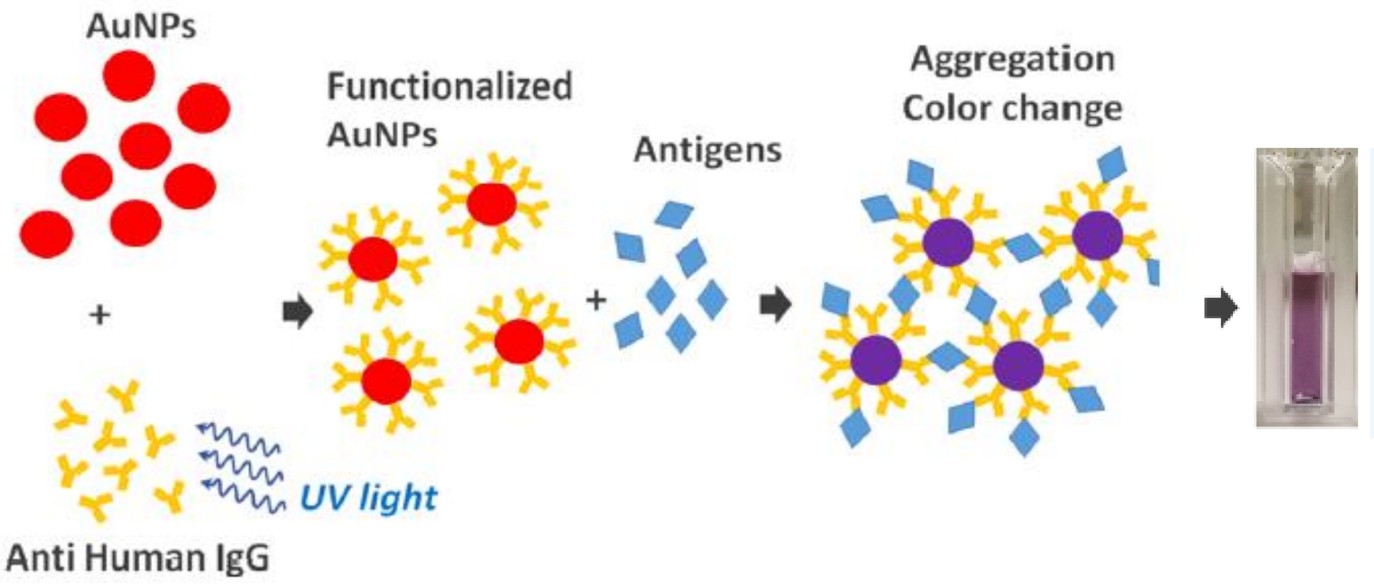
Metal nanoparticles aggregation

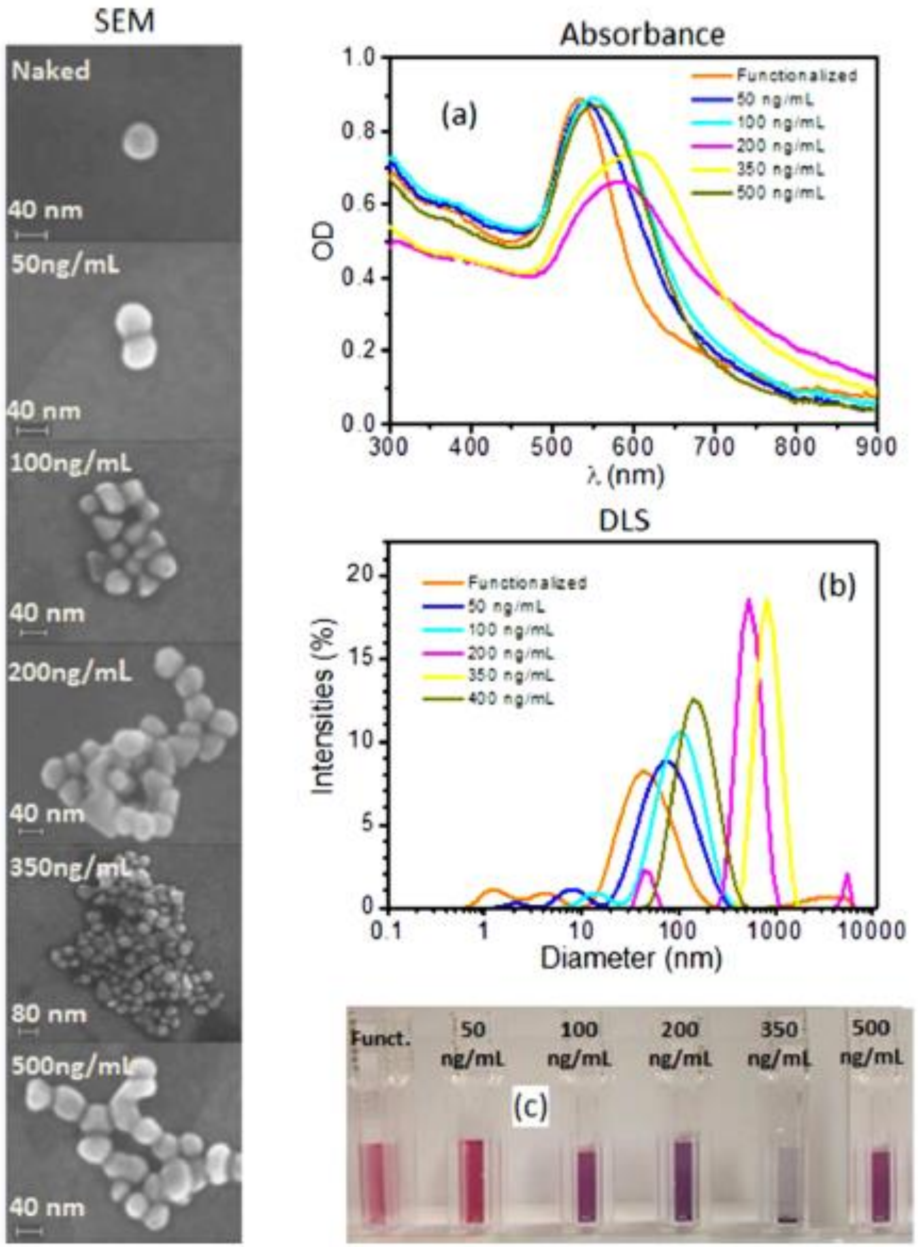
Main strategy



Metal nanoparticles aggregation

Immuno-based determination of HIgG





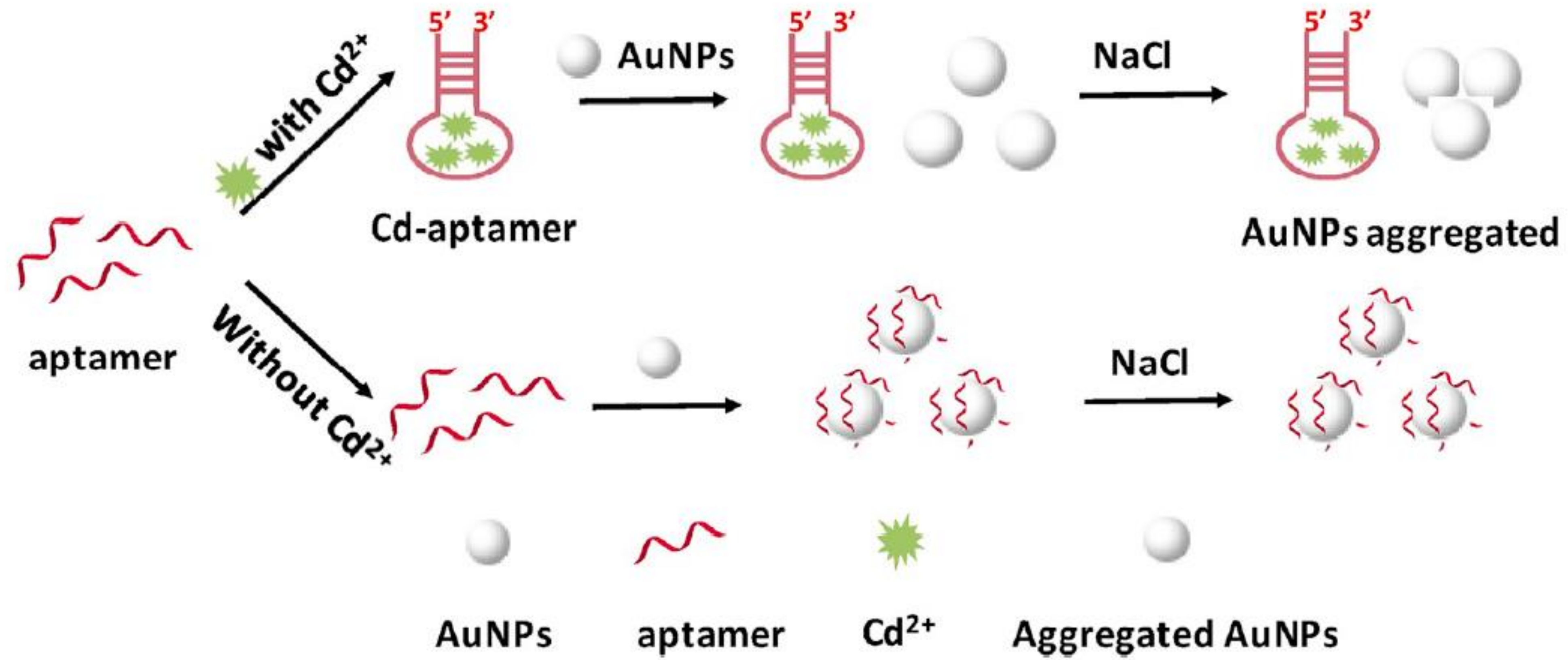
ACS OMEGA
Article
Cite This: ACS Omega 2018, 3, 3805−3812

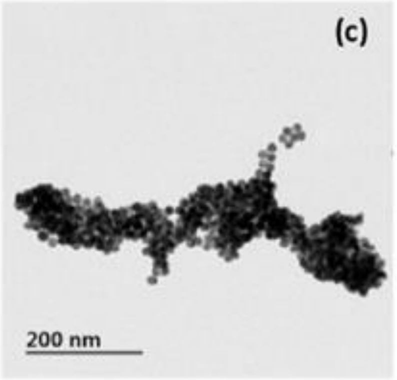
Colorimetric Immunosensor by Aggregation of Photochemically Functionalized Gold Nanoparticles

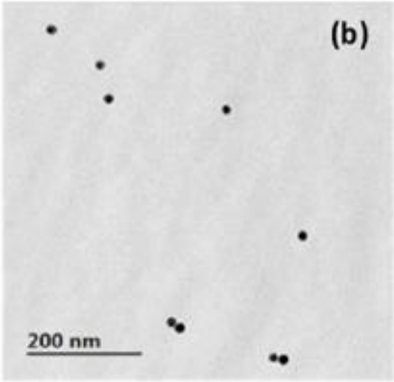
Marzia Iarossi,[†,∥] Chiara Schiattarella,[†,‡] Ilaria Rea,[‡] Luca De Stefano,[‡] Rosalba Fittipaldi,[§] Antonio Vecchione,[§] Raffaele Velotta,[*,†] and Bartolomeo Della Ventura[†]

Metal nanoparticles aggregation

Cd^{2+} indirect determination trough AuNPs aggregation







Talanta 208 (2020) 120231

Contents lists available at ScienceDirect

Talanta

journal homepage: www.elsevier.com/locate/talanta

In-situ detection of cadmium with aptamer functionalized gold nanoparticles based on smartphone-based colorimetric system

Ying Gan[a,b], Tao Liang[a], Qiongwen Hu[a], Longjie Zhong[a], Xinyi Wang[a], Hao Wan[a,b,**], Ping Wang[a,b,*]

Metal nanoparticles aggregation

Cd^{2+} indirect determination assay format

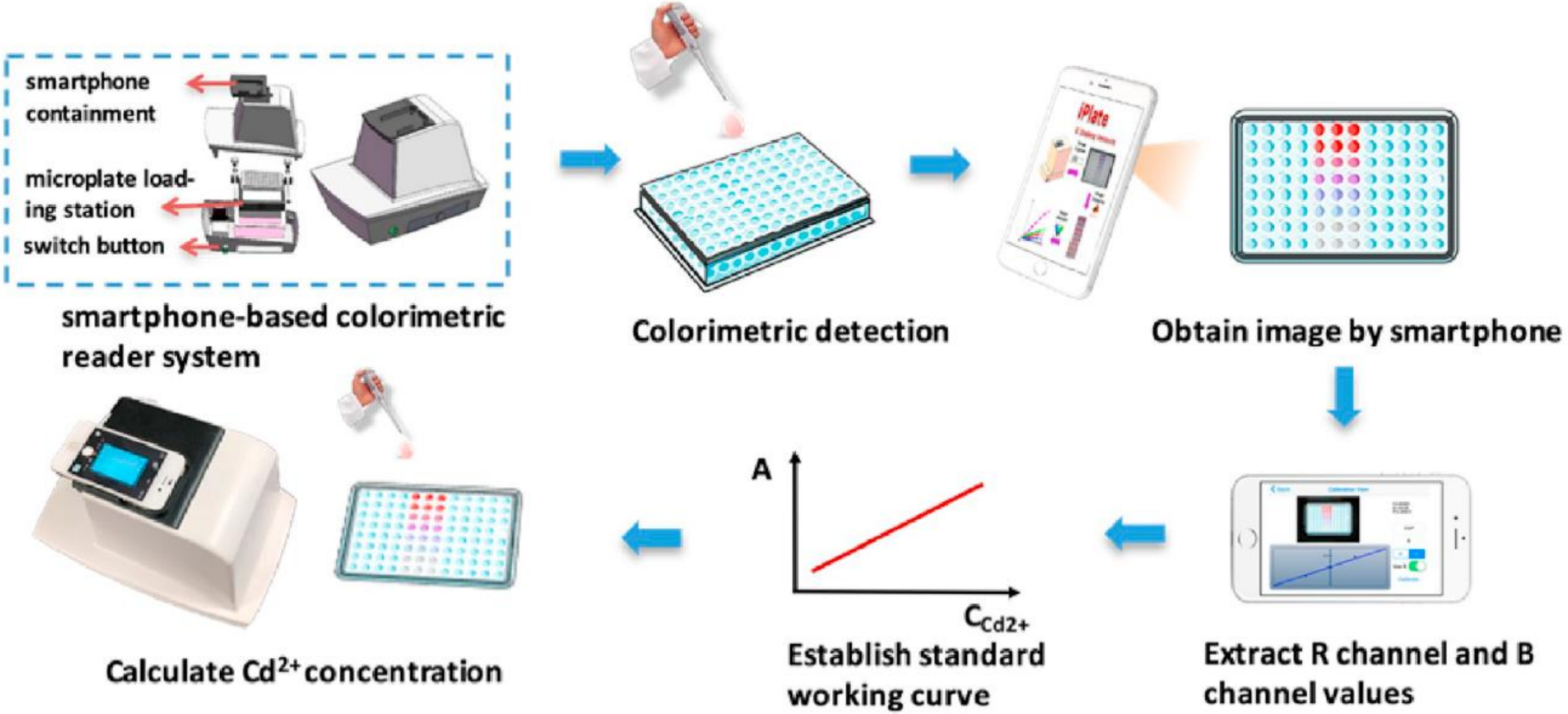
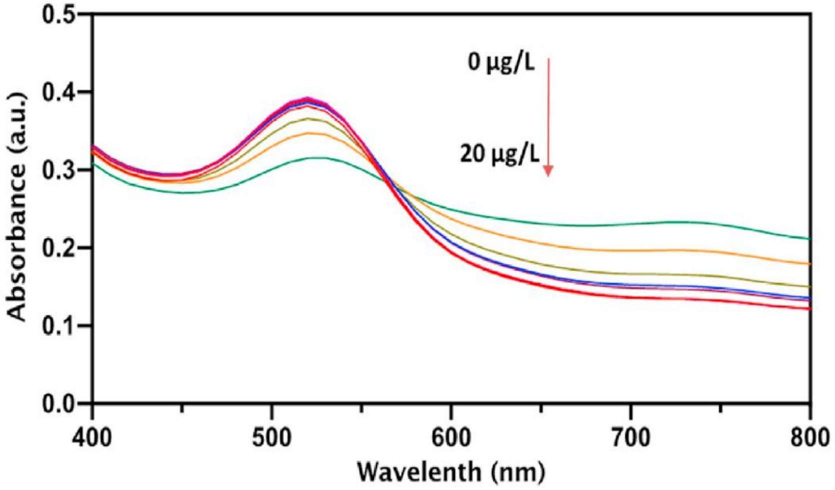


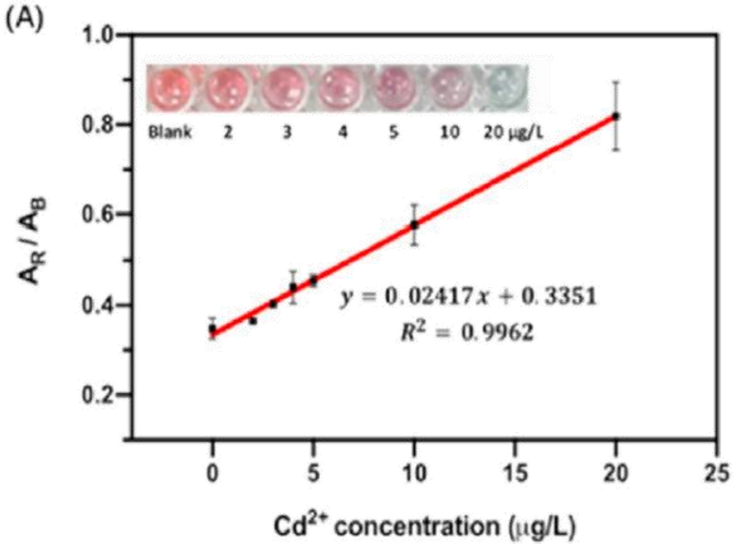
Fig. 2. Detection process of smartphone based colorimetric reader system.

Metal nanoparticles aggregation

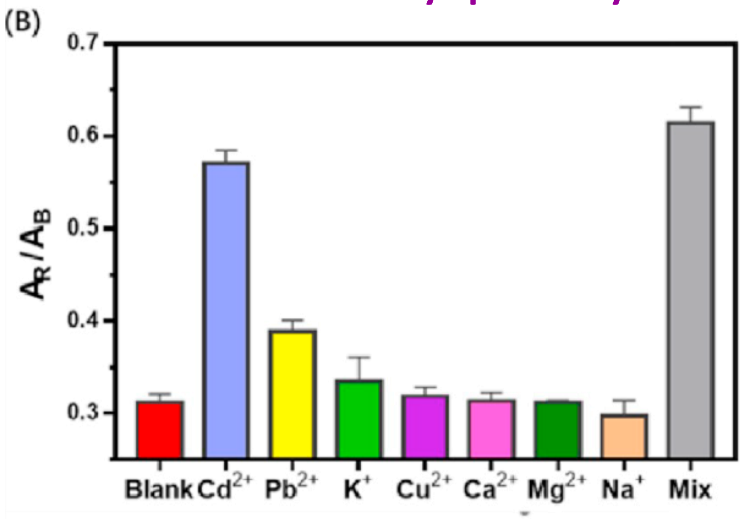
Cd^{2+} indirect determination

Dose-response curve





Colorimetric assay specificity



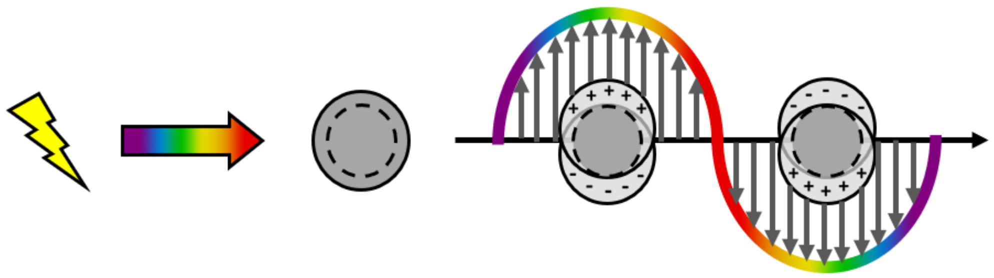
Recovery study

Determination of Cd^{2+} in tap water samples using the proposed method.

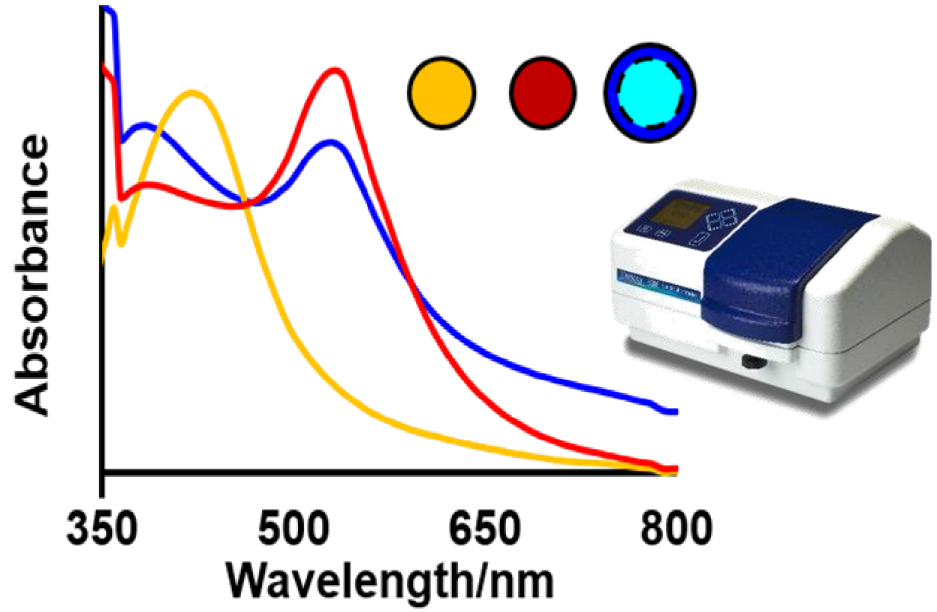
Samples	Spiked concentration (μg/L)	This colorimetric system		Microplate reader	
		Determined conc. (μg/L)	Recovery%	Determined conc. (μg/L)	Recovery%
1	5	5.18	116.4	5.21	104.3
2	10	11.32	113.2	10.96	109.6
3	10	11.61	116.1	10.83	108.3
4	20	21.63	108.15	20.12	100.6
5	20	23.56	117.8	22.15	110.8

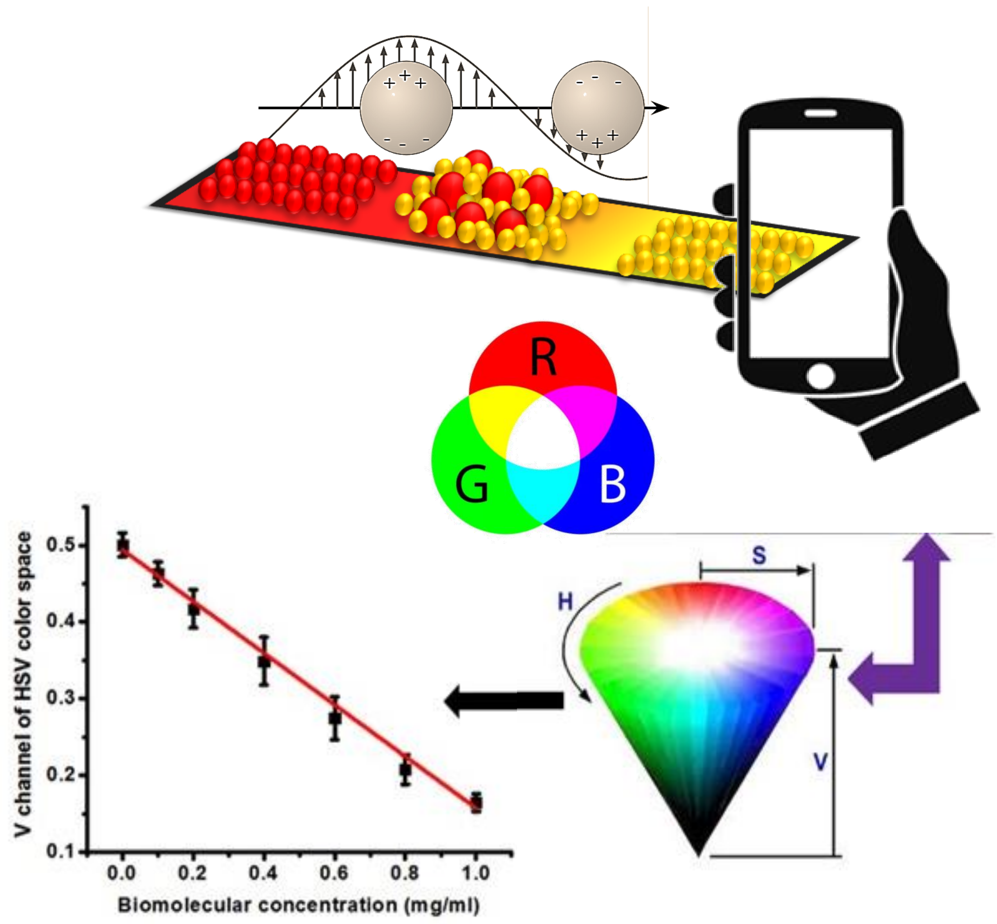
Colorimetric approach

From plasmonic… Towards colorimetric strategies



Localized Surface Plasmon Resonance





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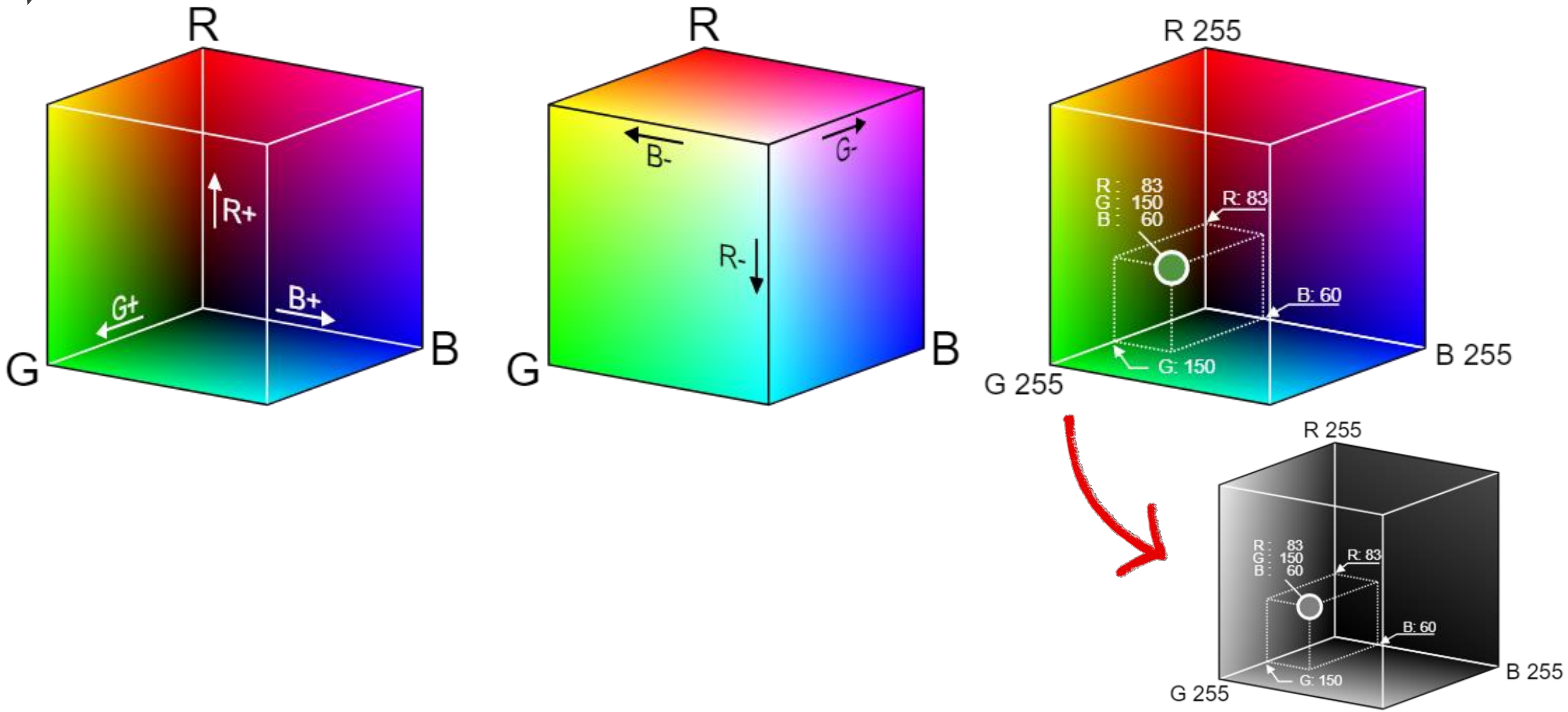
Optical spectroscopic methods/ Spectrochemical methods.

WHICH COLOR I PERCEIVE?

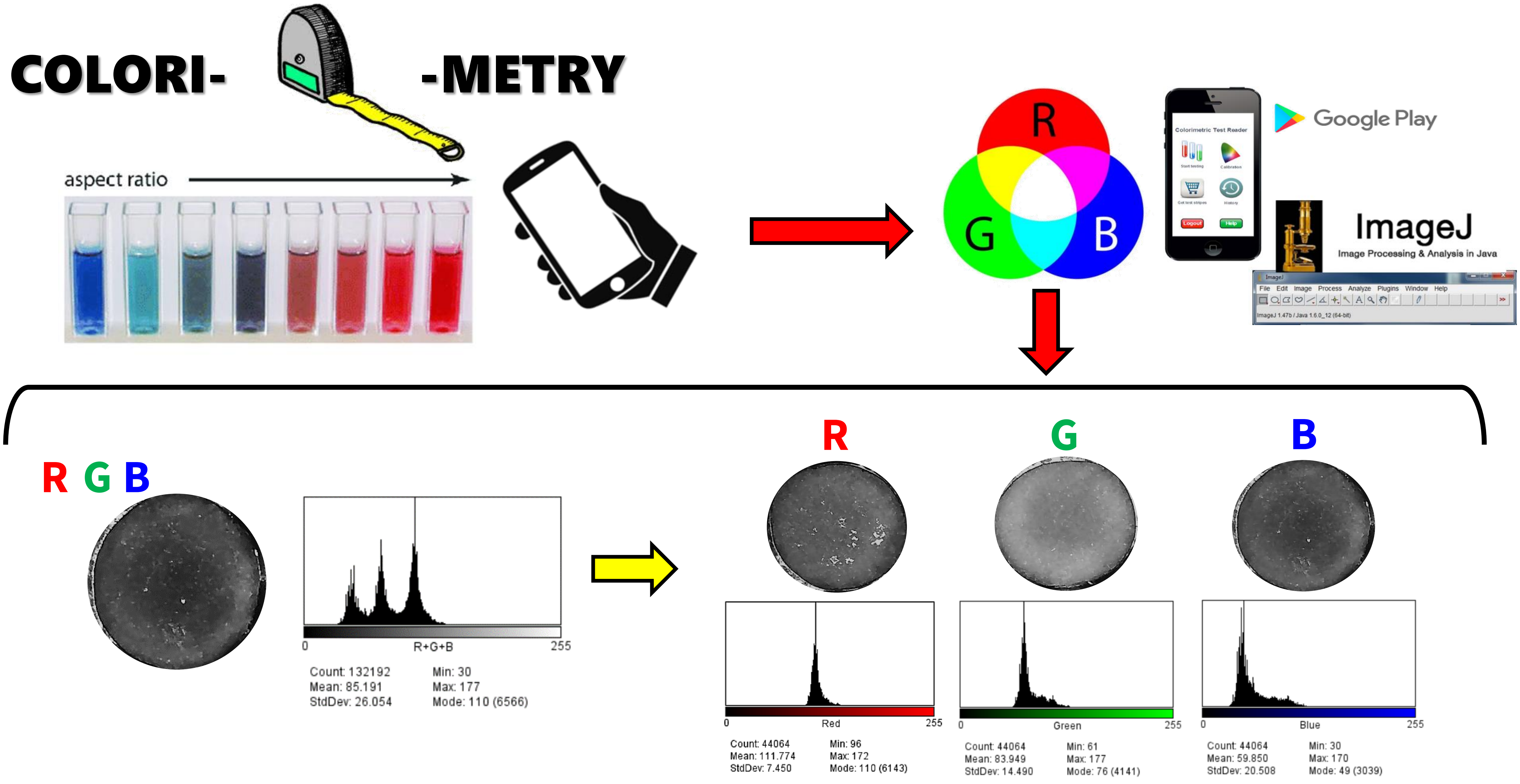
The Visible Spectrum

Wavelength Region Absorbed, nm	Color of Light Absorbed	Complementary Color Transmitted
400–435	Violet	Yellow-green
435–480	Blue	Yellow
480–490	Blue-green	Orange
490–500	Green-blue	Red
500–560	Green	Purple
560–580	Yellow-green	Violet
580–595	Yellow	Blue
595–650	Orange	Blue-green
650–750	Red	Green-blue

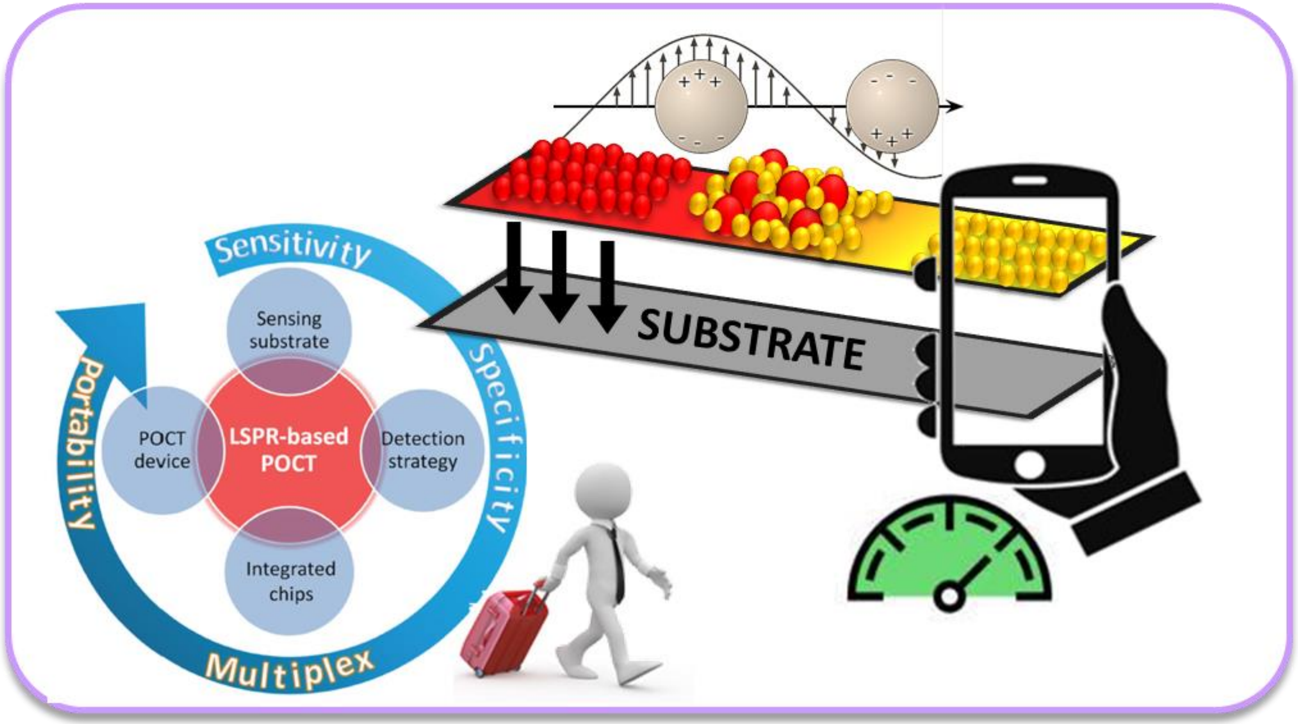
RGB COLORIMETRIC SPACE

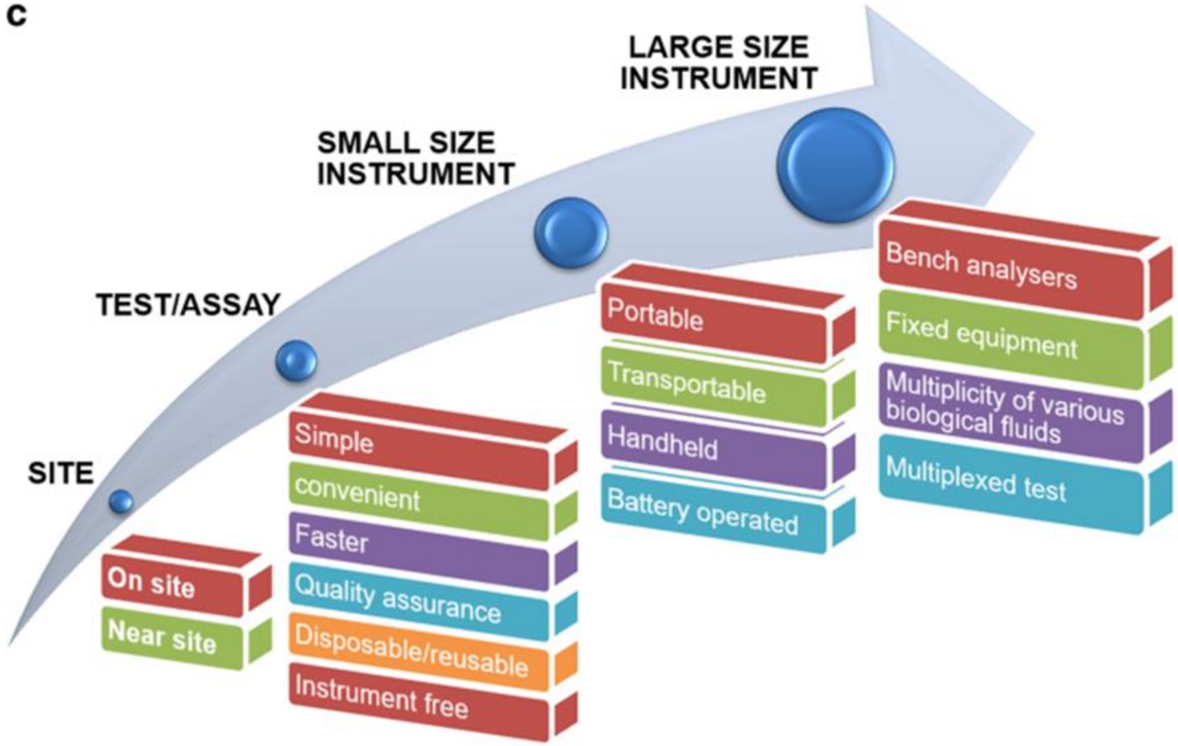


COLORIMETRY PILLAR



Metal nanoparticles integration onto solid substrates





!!! Lab-on-a-strip Device !!!

Cost performance

Manufacturing

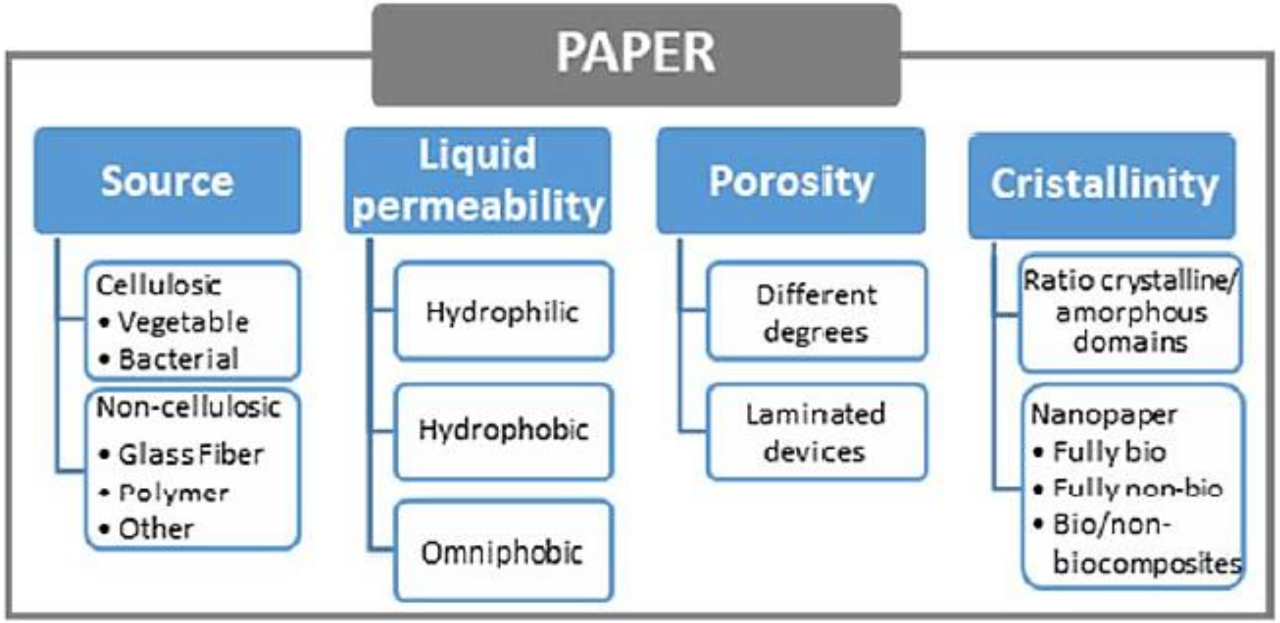
Mass production

Paper as substrate

Paper can…
Store
Filter
React

Drawbacks…
Reagents diffusion…
Electrical noise! ☹

An hydrophobic
barrier
is needed…



Paper as elective substrate

Paper tailorability

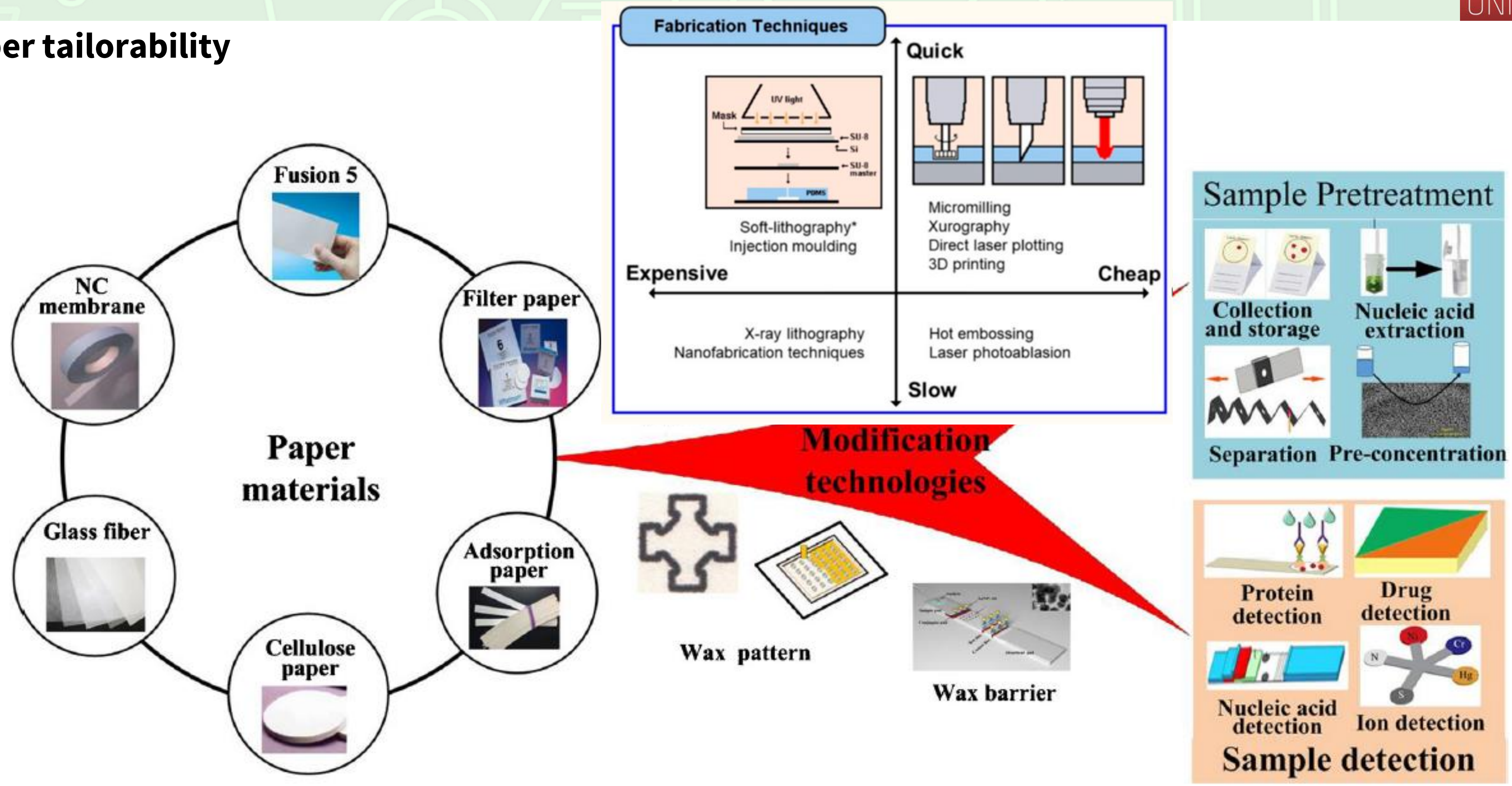


Fig. 1 Existing paper modification approaches for paper-based POCT. Different paper materials, including Fusion 5, filter paper, chromatography paper, cellulose paper, Whatman® No.1 filter paper and NC membrane, have been modified with various reagents for paper-based sample pretreatment and paper-based detection

MNPs as colorimetric probe

Analytica Chimica Acta 1183 (2021) 338971

Contents lists available at ScienceDirect

Analytica Chimica Acta

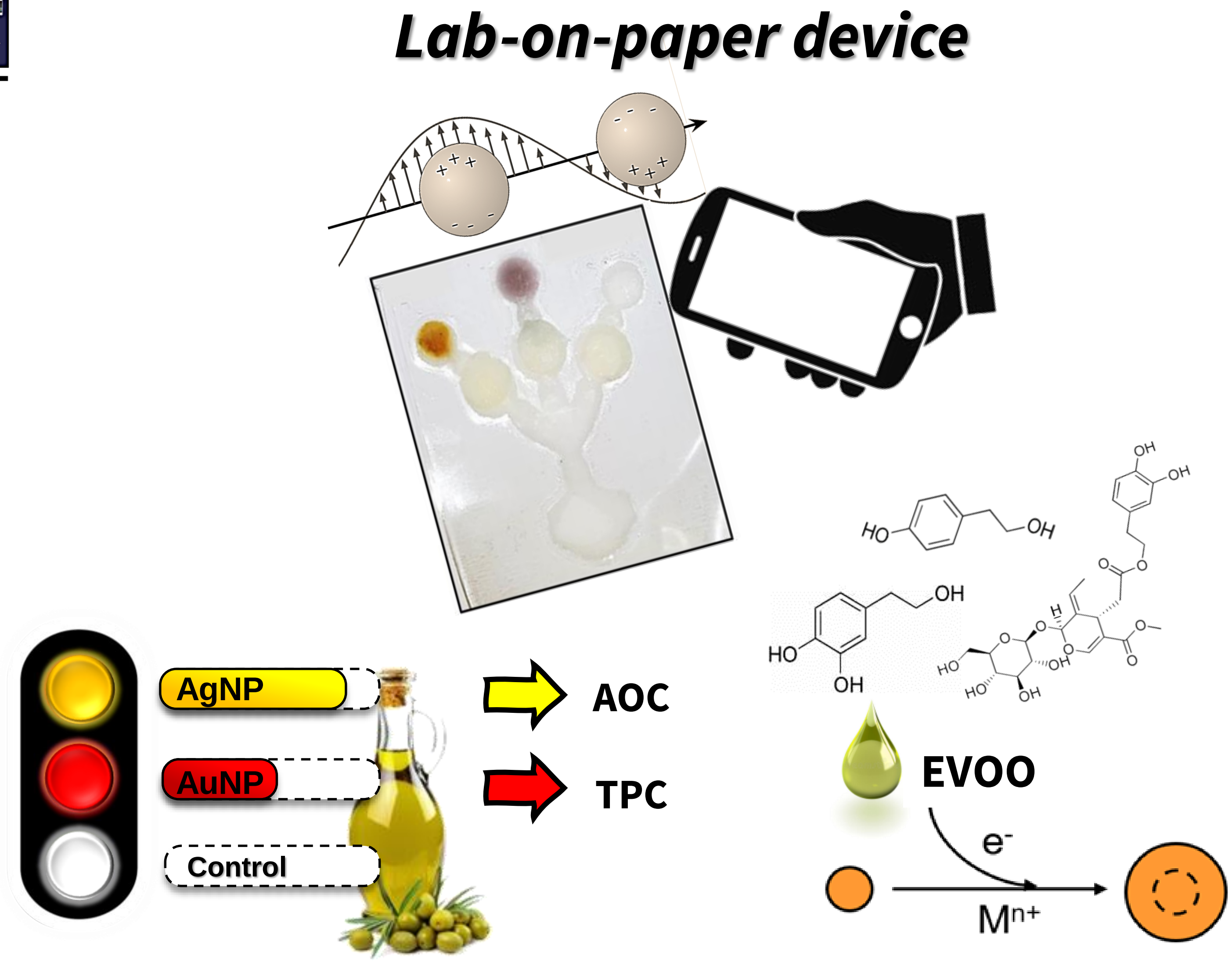
journal homepage: www.elsevier.com/locate/aca

Metal nanoparticles based lab-on-paper for phenolic compounds evaluation with no sample pretreatment. Application to extra virgin olive oil samples

Annalisa Scroccarello [a], Flavio Della Pelle [a,*], Daniel Rojas [a], Giovanni Ferraro [b], Emiliano Fratini [b], Sara Gaggiotti [c], Angelo Cichelli [c], Dario Compagnone [a,**]

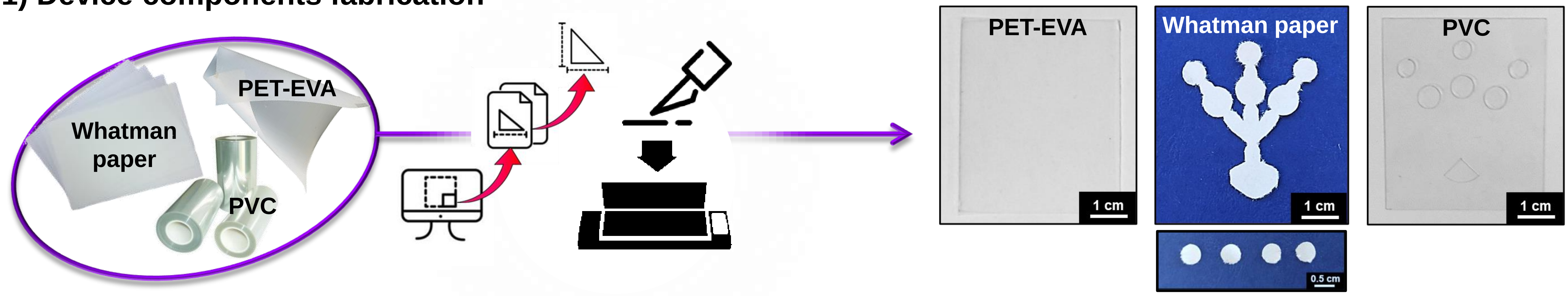
Office grade instruments

Thermal-roll laminator

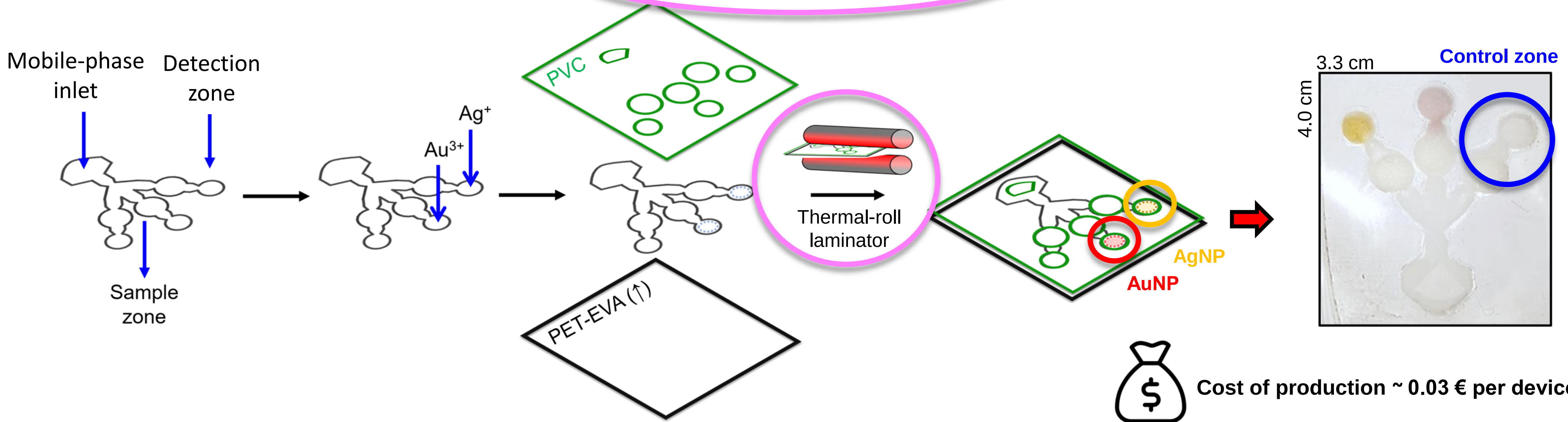


MNPs as colorimetric probe: Device conceptualization and realization

1) Device components fabrication



2) Device assembling and sensing elements (AgNP and AuNP) formation



Cost of production ~ 0.03 € per device

MNPs as colorimetric probe: Extraction-free phenolic compounds determination

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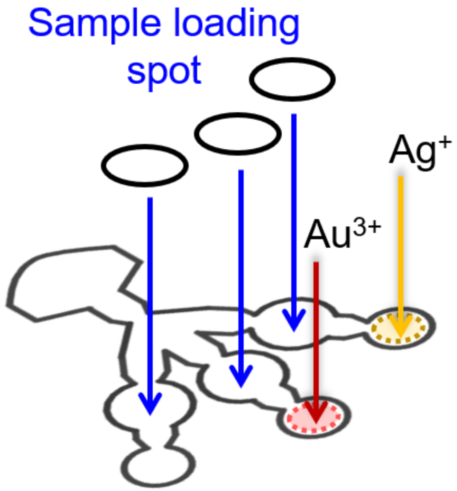
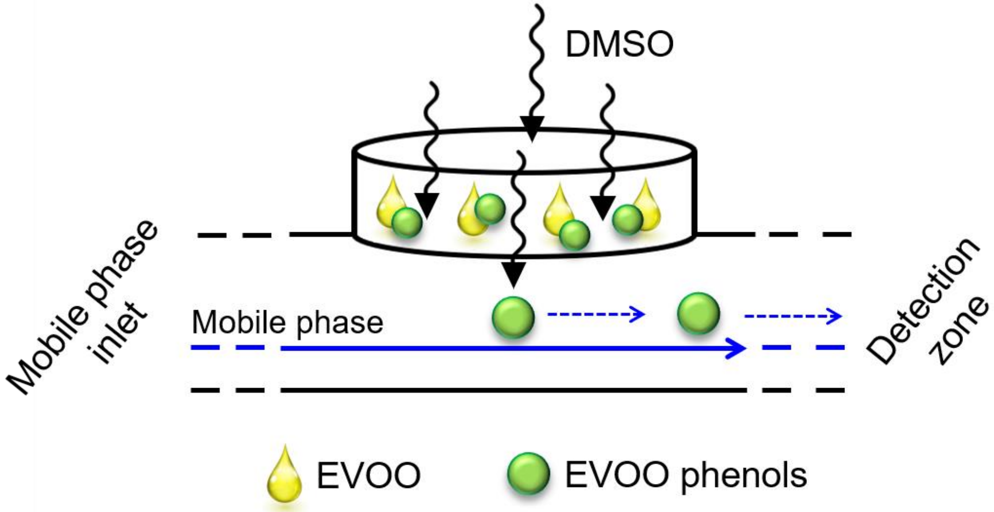
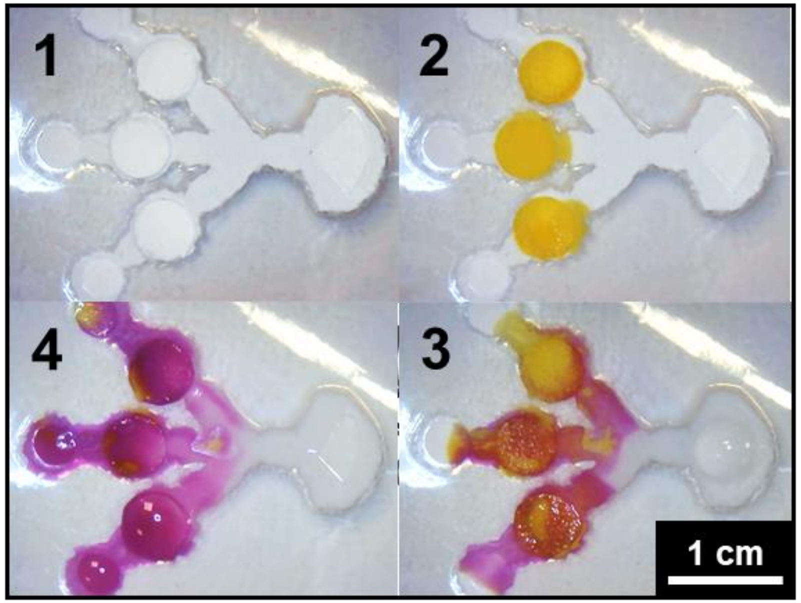
Extraction-free olive oil phenolic compounds evaluation through a MNPs seed growth strategy

Assay format





Assay simulation with a colorimetric dye



Paper-based colorimetric sensor

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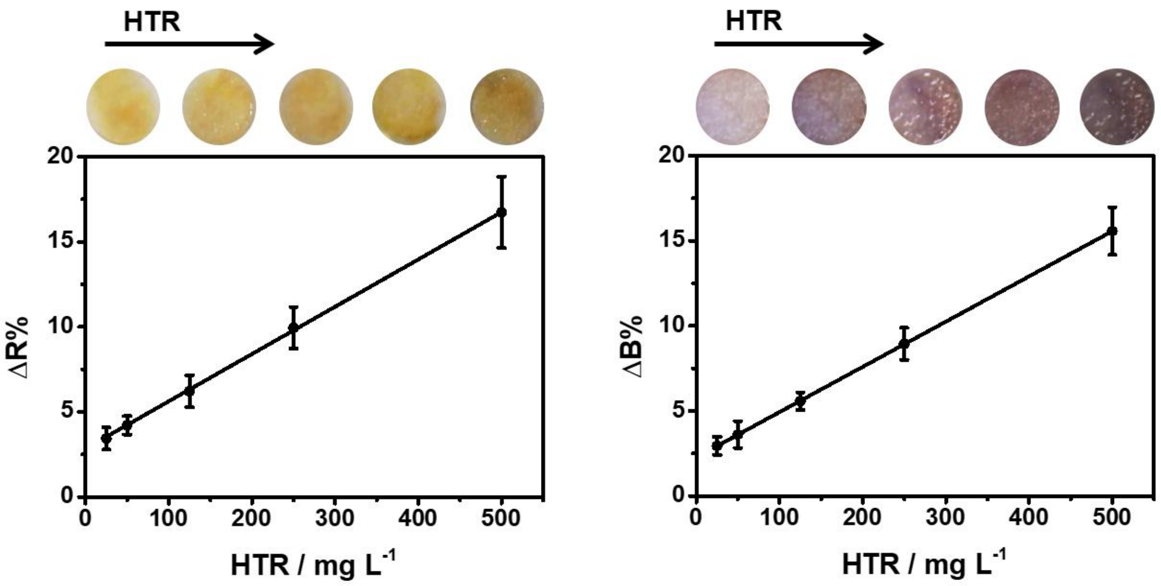
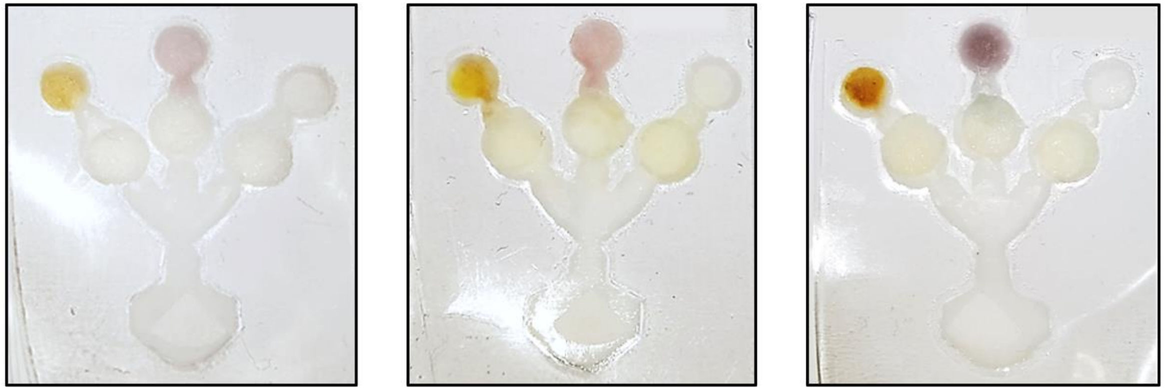
Extraction-free olive oil phenolic compounds evaluation trough a seed growth strategy

Dose-response curve

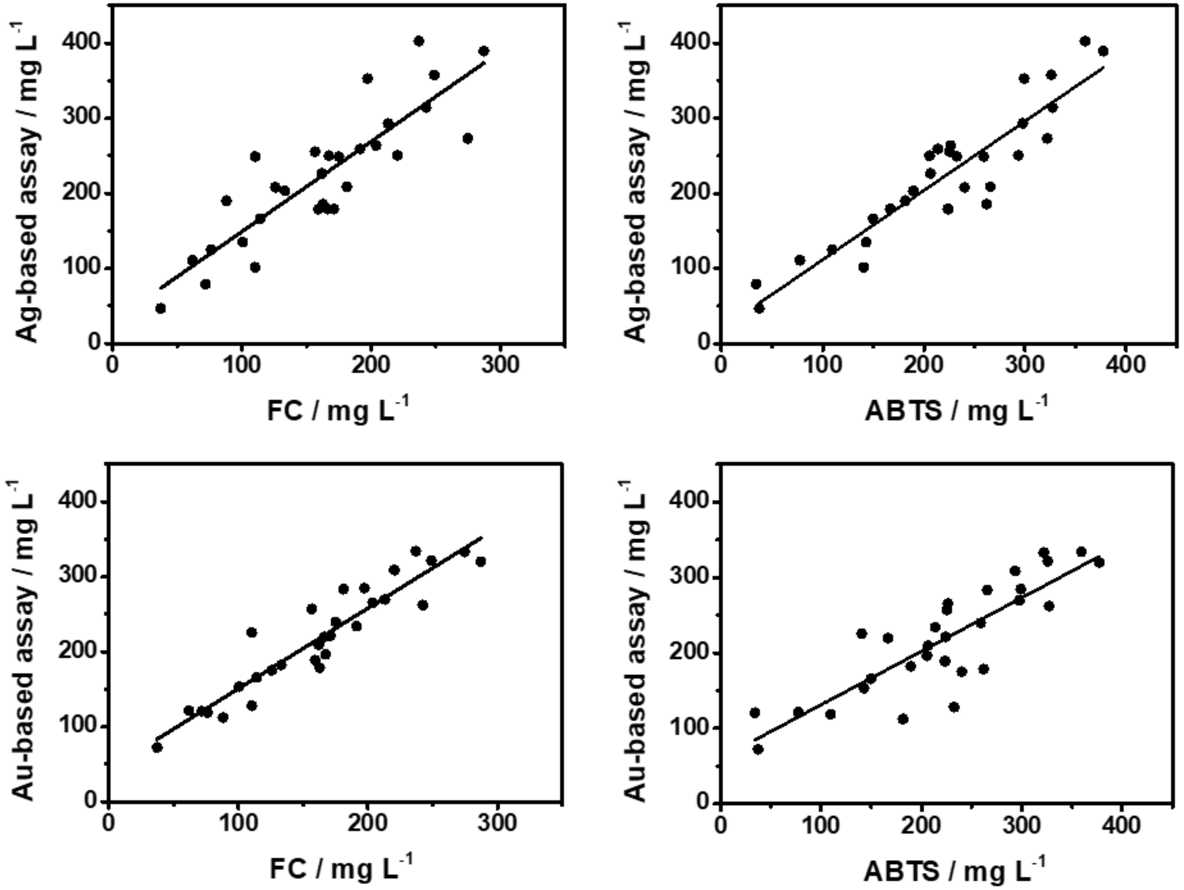


EVOO samples' phenolyc compounds content



Low Mean High

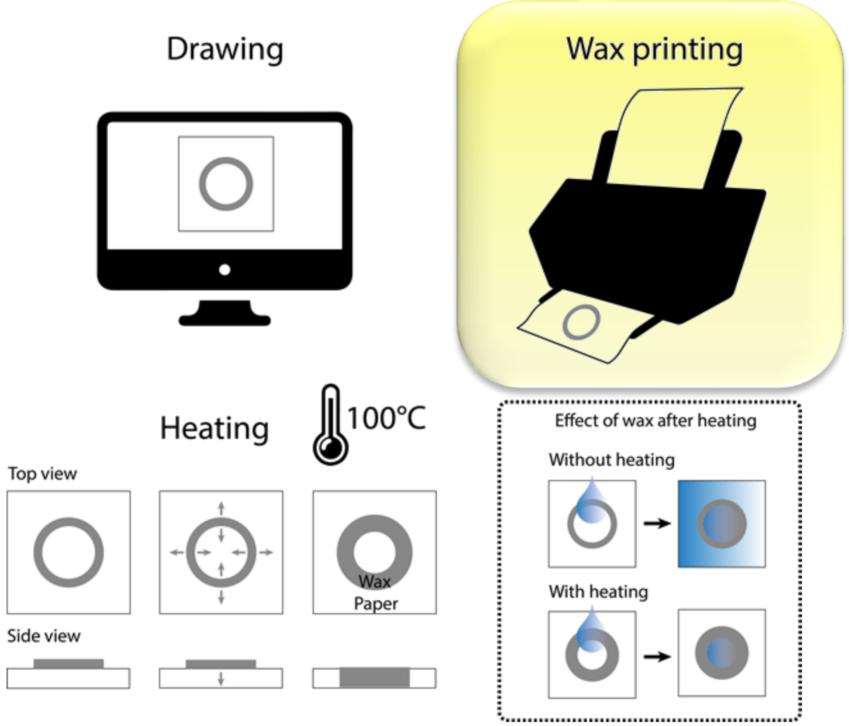
Sample analysis, analytical performances

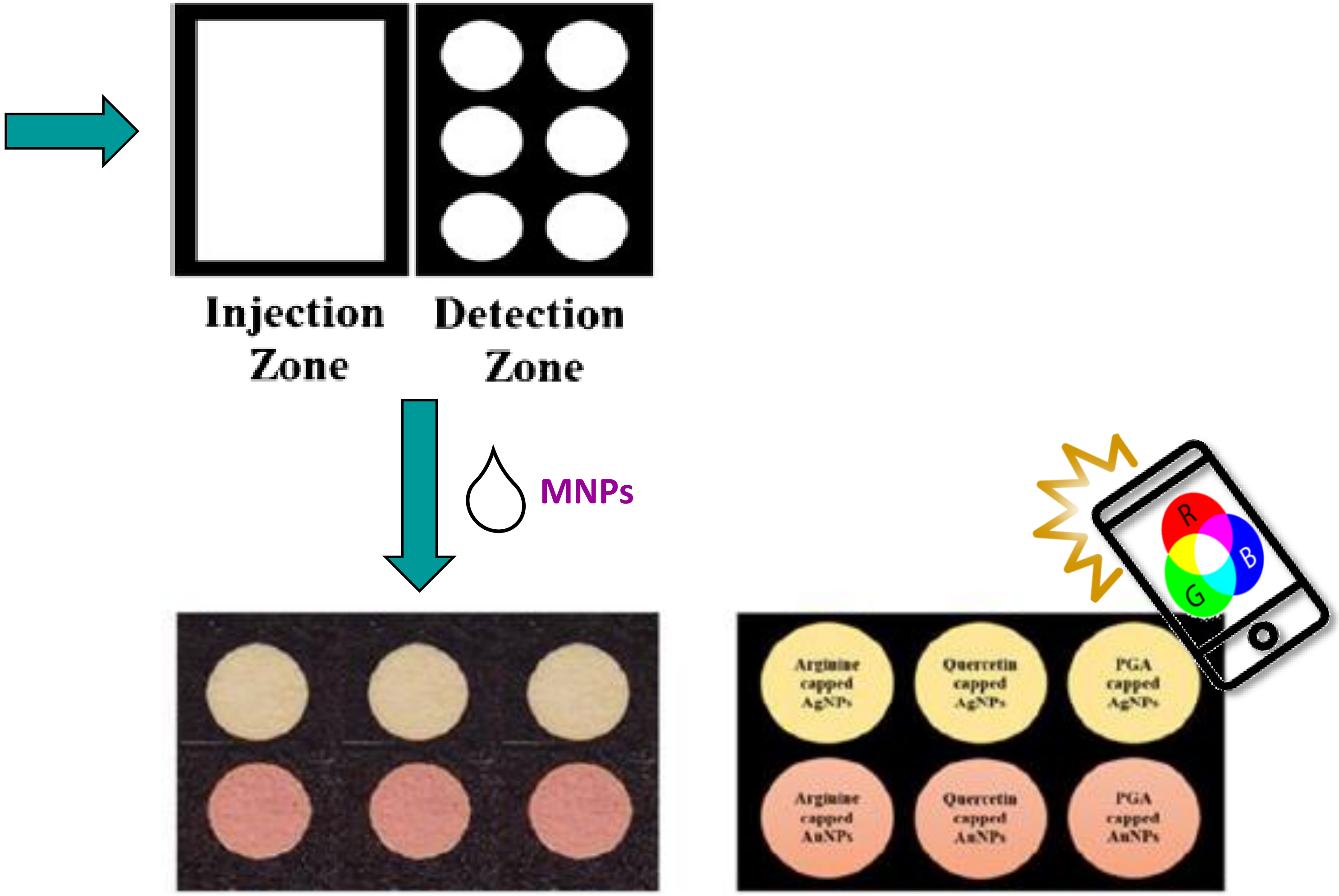


No interterferences by compounds commonly present in EVOO

Paper-based colorimetric sensor

Pesticides determination trough MNPs aggregation integrated in a paper-based device





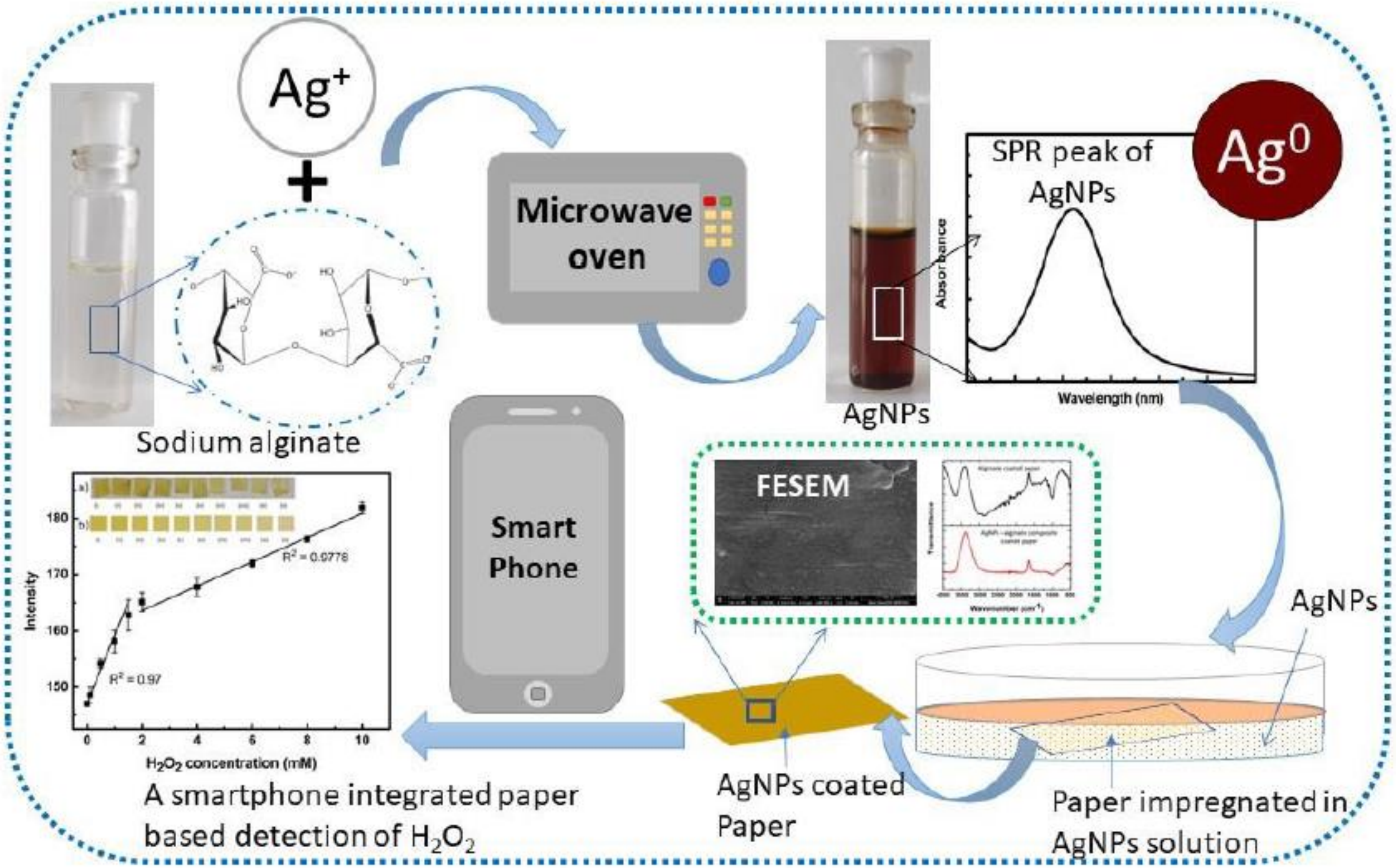
Microchimica Acta (2020) 187:621
https://doi.org/10.1007/s00604-020-04596-x
ORIGINAL PAPER

A paper-based colorimetric sensor array for discrimination and simultaneous determination of organophosphate and carbamate pesticides in tap water, apple juice, and rice

Mohammad Mahdi Bordbar[1] · Tien Anh Nguyen[2] · Fabiana Arduini[3] · Hasan Bagheri[1]

Paper-based colorimetric sensor

H_2O_2 determination trough MNPs etching integrated in a paper-based substrate



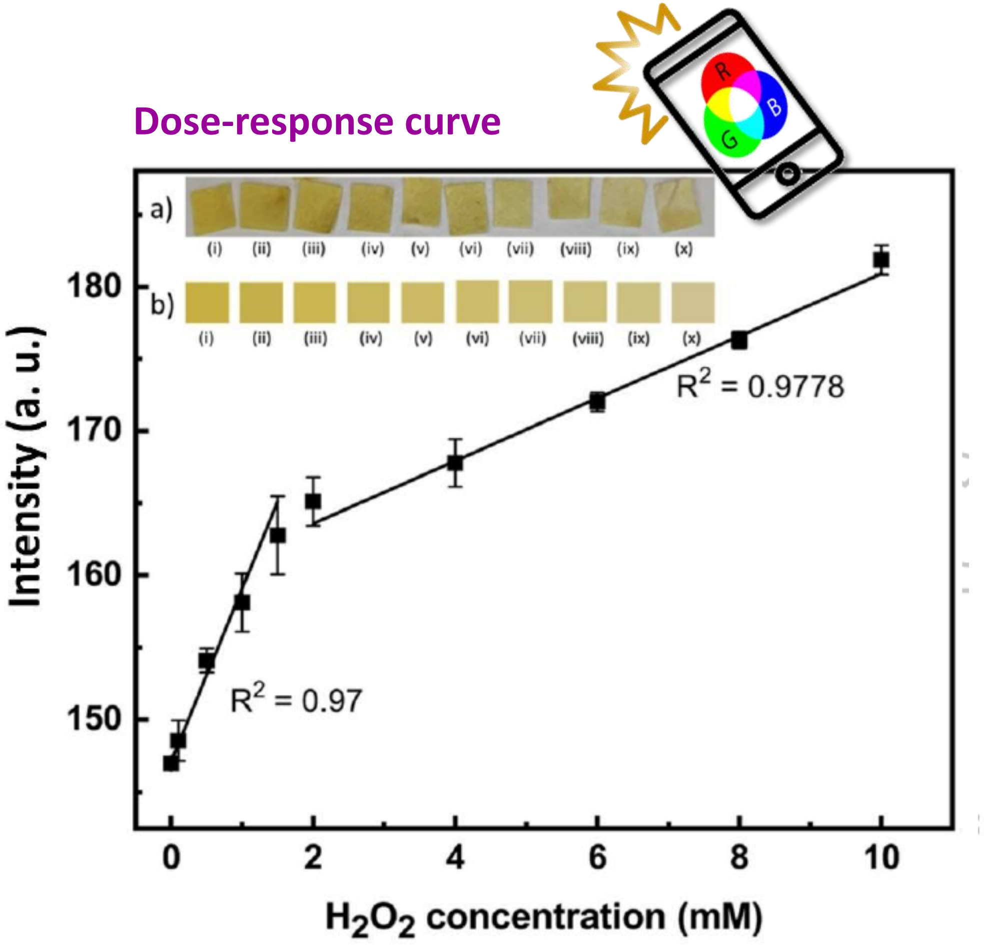
Articles

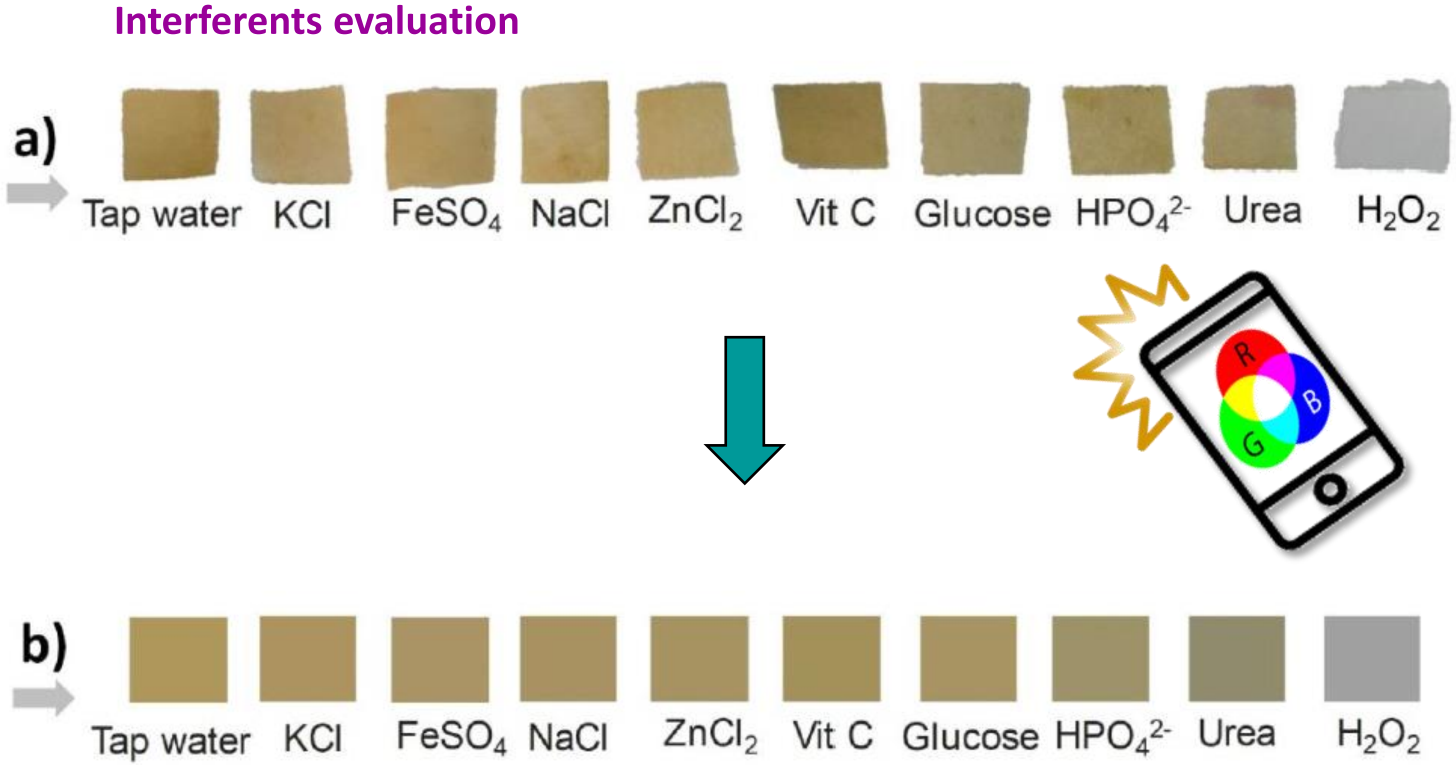
Development of a surface-modified paper-based colorimetric sensor using synthesized Ag NPs-alginate composite

Lokesh Sharma, Shubhankar Gouraj, Pranit Raut & Chandrakant Tagad

Paper-based colorimetric sensor

H_2O_2 determination trough MNPs etching integrated in a paper-based substrate





Paper-based colorimetric sensor

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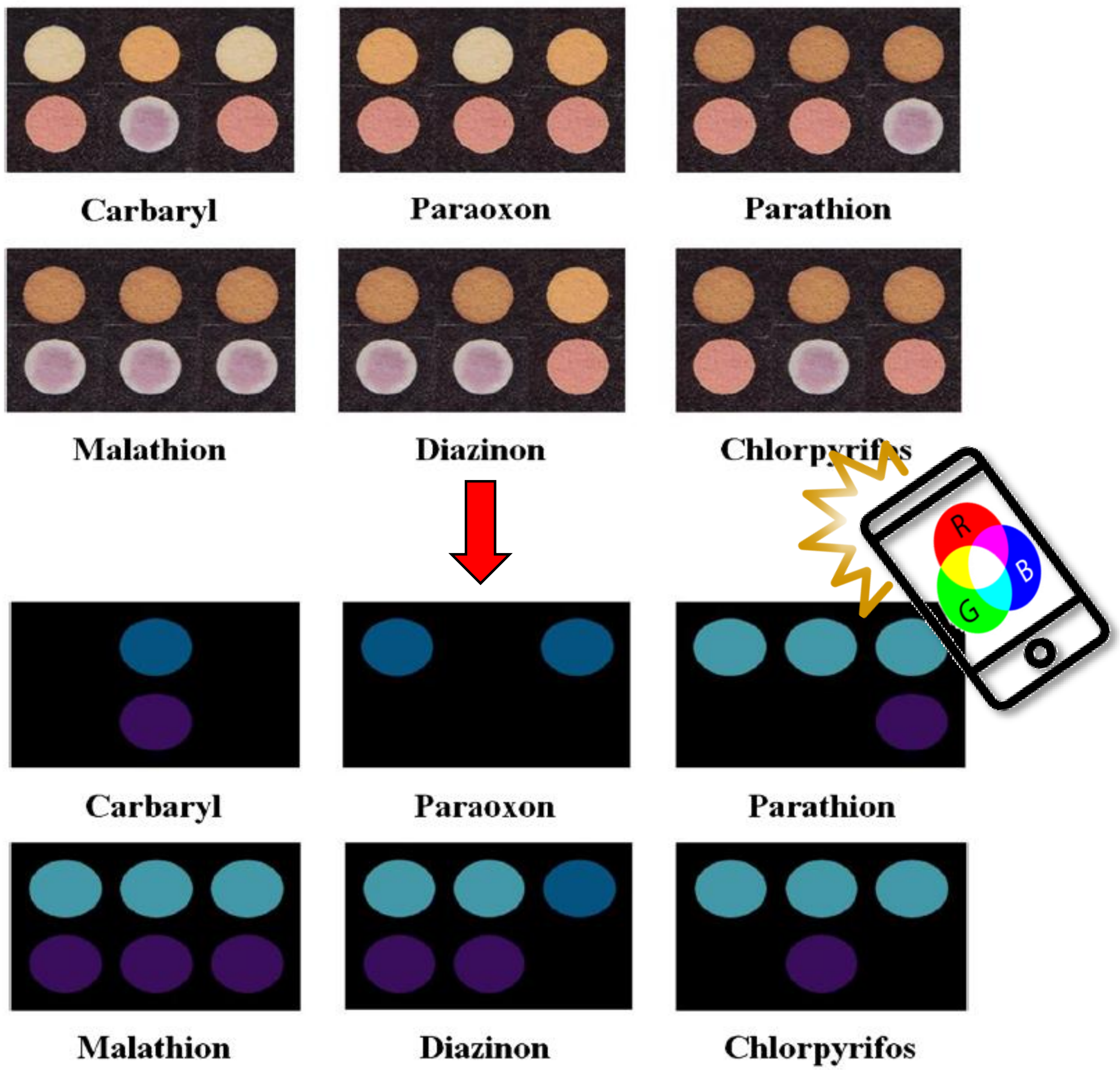
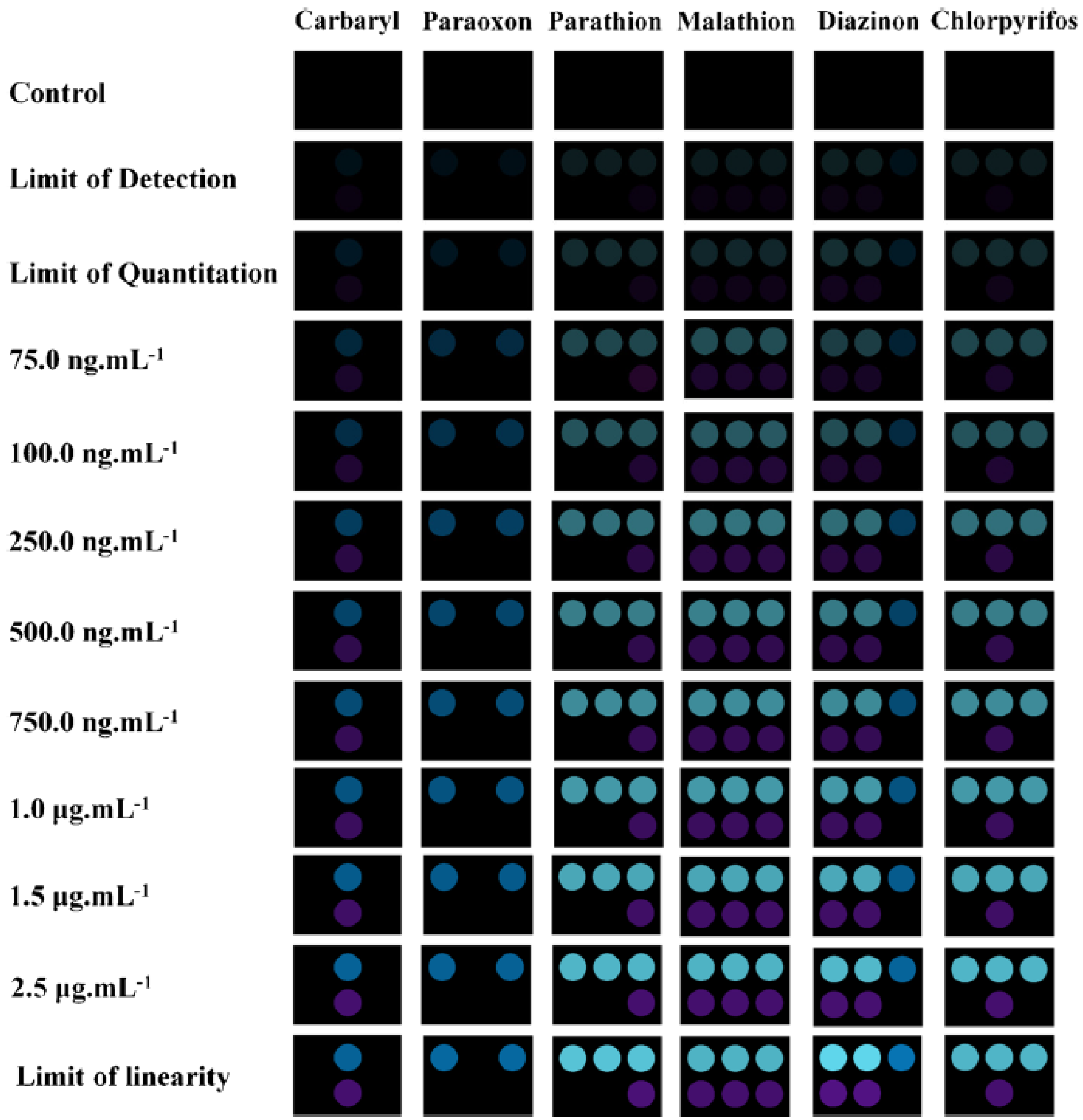
Pesticides determination trough MNPs aggregation integrated in a paper-based device

Analytes screening



Dose-response curve and analytical parameters



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