# Group of “Physical Chemistry of Macromolecules” in TRAHND

Eu projects:

SiGHT (FP6), 3MICRON (FP7), TheraGlio (FP7), AMPHORA (H2020)

Activities

- “Smart” platforms for biomedicine:
  - Imaging: ultrasound, Magnetic resonance, PET-SPECT
  - Targeted Drug release

Theranostics

People:

Gaio Paradossi (full professor)

Fabio Domenici (Researcher)

Ester Chiessi (Researcher)

Letizia Oddo (Assegnista)

Barbara Cerroni (assegnista)

Yosra Toumia (Assegnista)

Damiano Palmieri (PhD Student)

Flavia Righi Riva (Student)

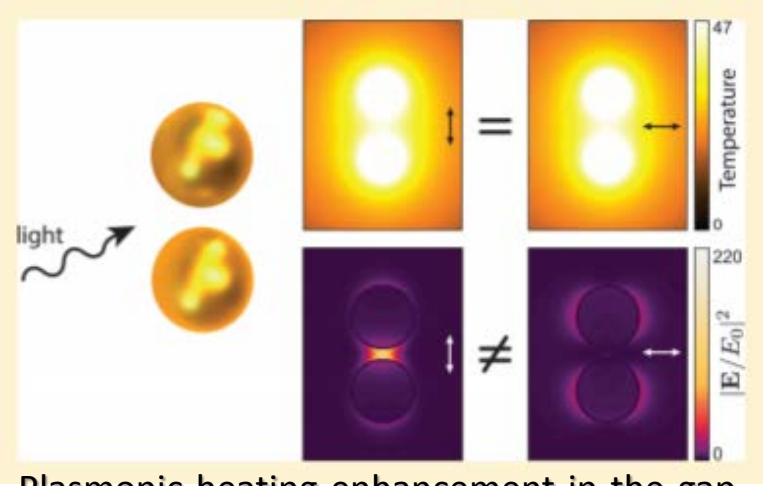
# Transfer of RAdiative Heat in Nano Devices: "TRAHND"

Expertise relevant for the project:

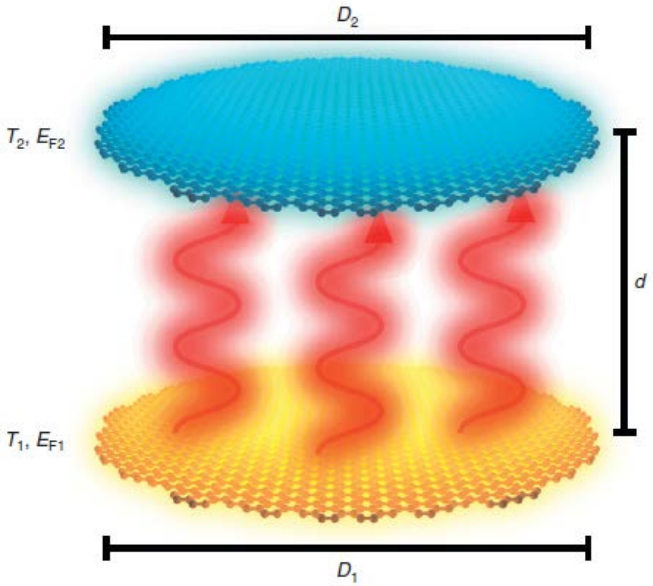
Integration of hybrid thermoresponsive polymer platforms with **pristine** graphene and gold nanoparticles.

# Near-field radiative heat transfer (TRH): The heat through the gap

*Experiments show that the radiative heat transfer between two closely spaced surfaces can be two to three orders of magnitude higher than Planck's law for the far field would predict.*

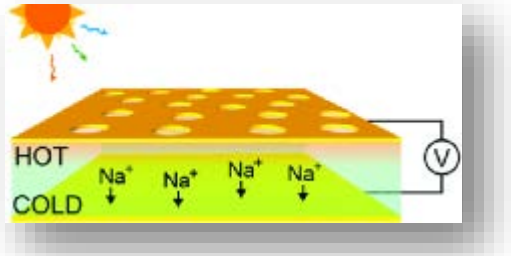


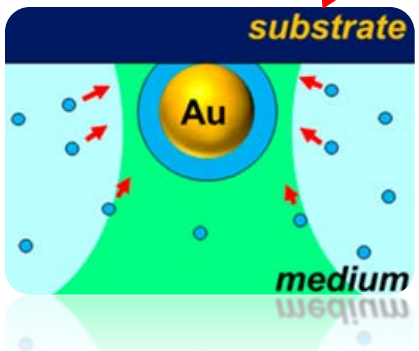

Plasmonic heating enhancement in the gap of two colosely spaced Au Nanospheres

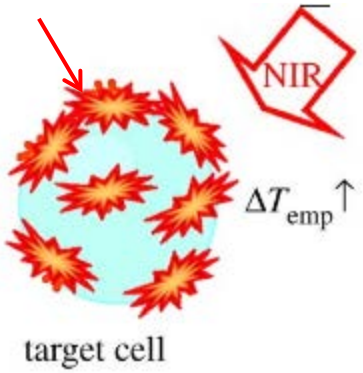



Heat transfer between two parallel coaxial graphene disks placed in vacuum and separated by a small distance d ~10nm

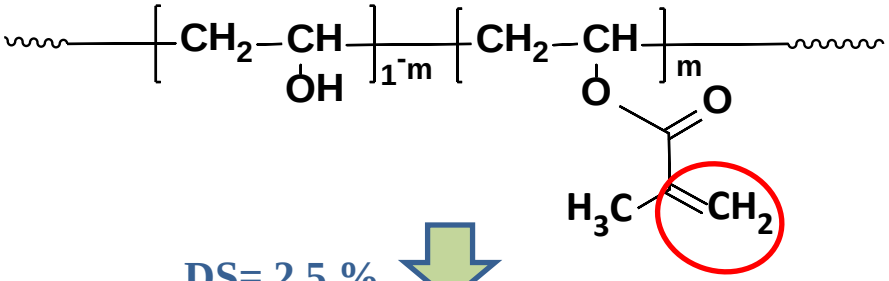
*This is of great importance to a variety of material/biomateiral technologies as heat-assisted magnetic recording, near-field thermophotovoltaics, lithography, sensing and theranostics*



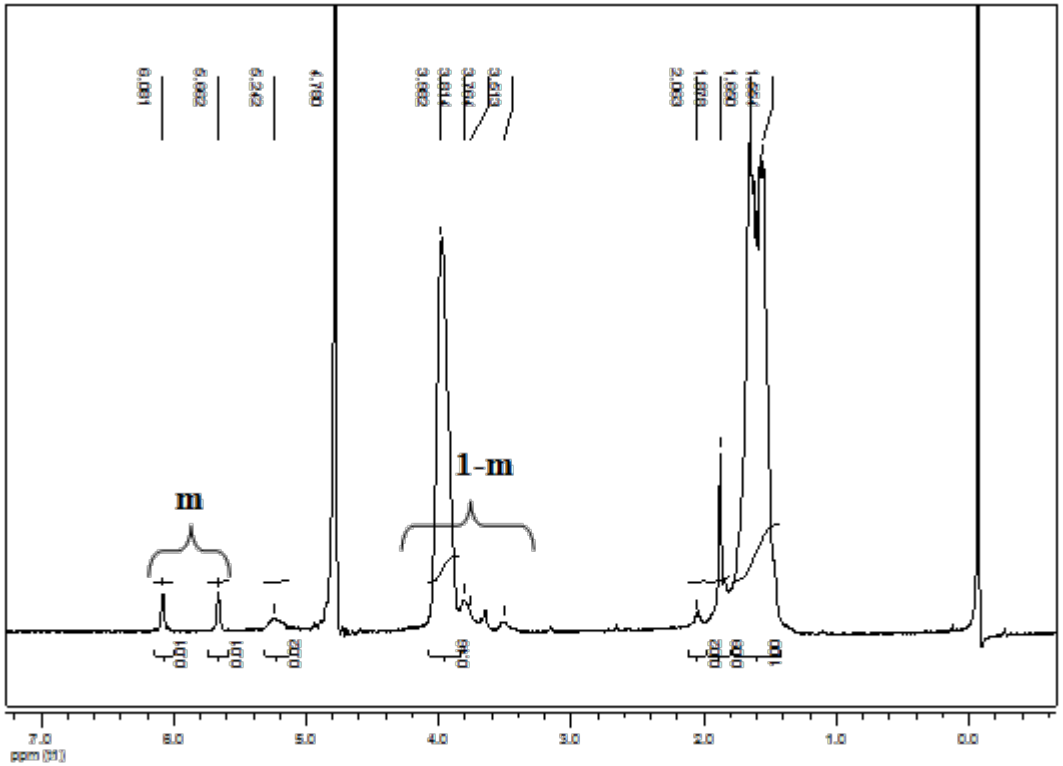



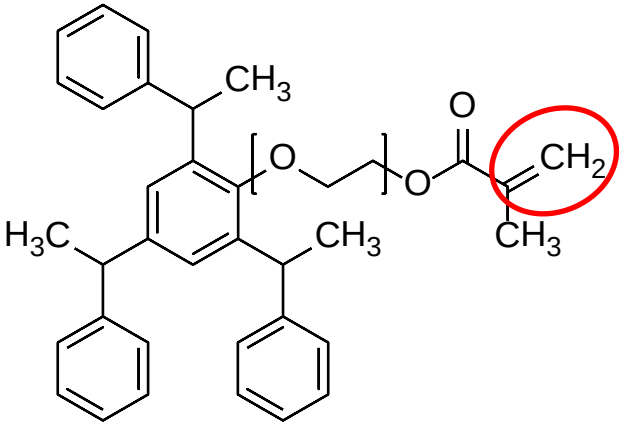
## Polyvinyl alcohol Methacrylate (PVA-MA)



DS= 2.5 %

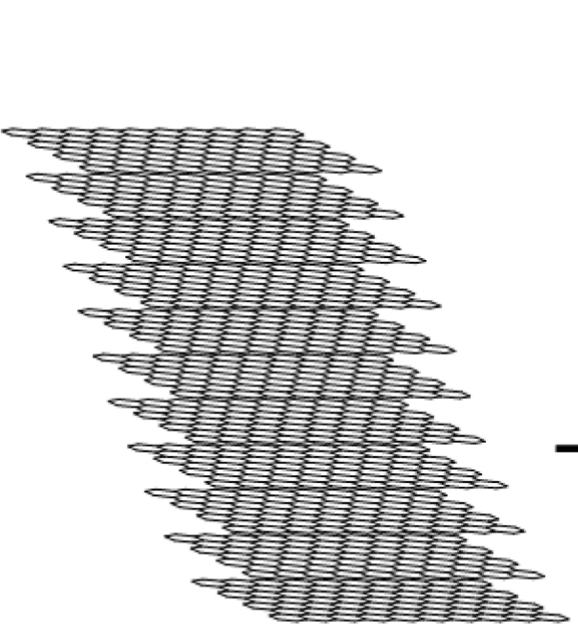



## CHOICE OF THE SURFACTANT ?

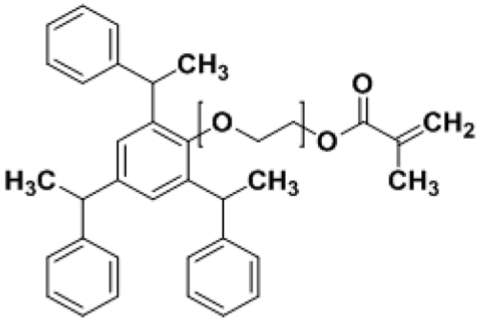


**PEG-PEPEMA** **(Poly(ethylene glycol) 2,4,6-tris(1-phenylethyl) phenyl ether methacrylate )**

# Graphene Exfoliation by Surfactant Assisted Ultrasonication



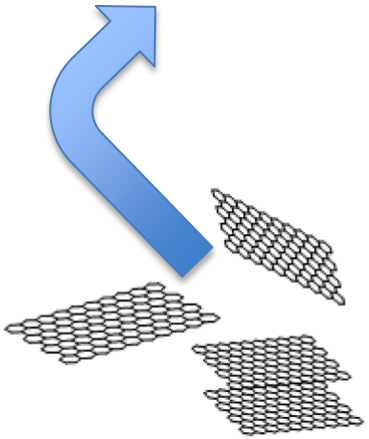
Graphite

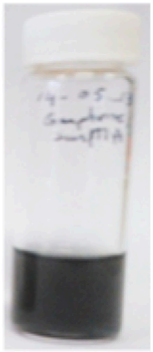



PEG-PEPEMA

Ultrasonication, Centrifugation

Pristine graphene !

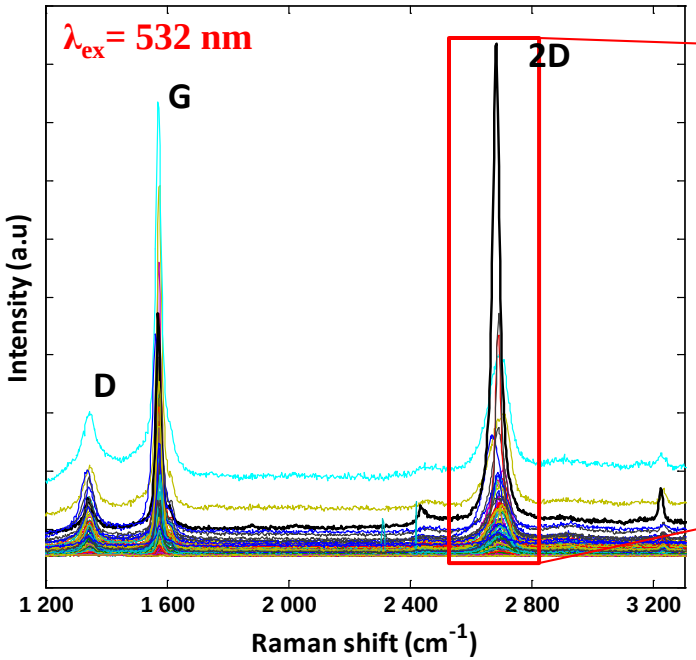


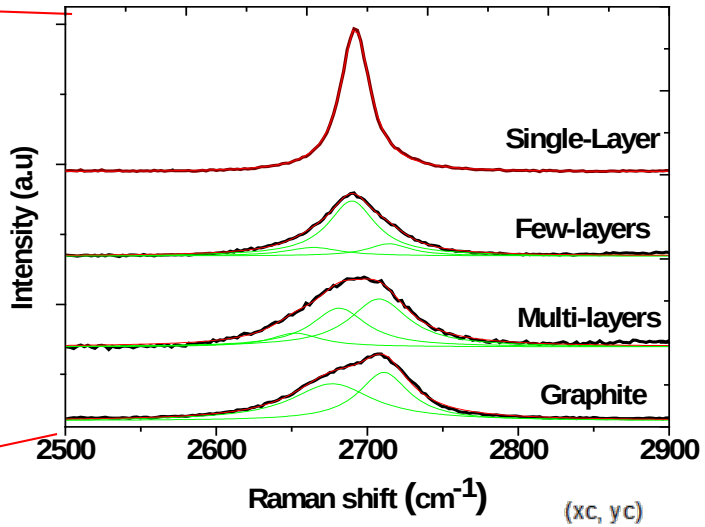


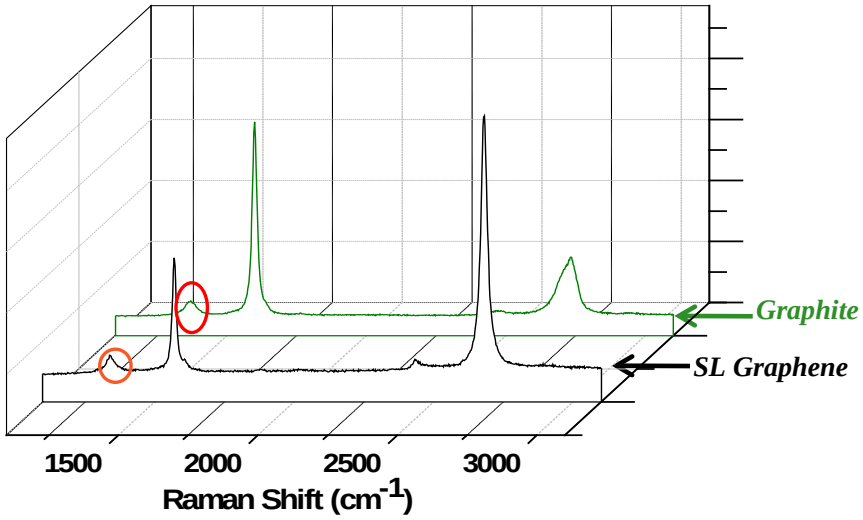
Single and few-layered graphene sheets aqueous dispersion

Paradossi et al. J. Phys. Chem. B 2015, 119, 2051−2061

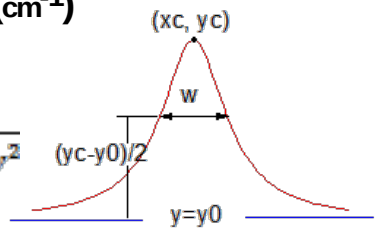
# Graphene Raman Characterization



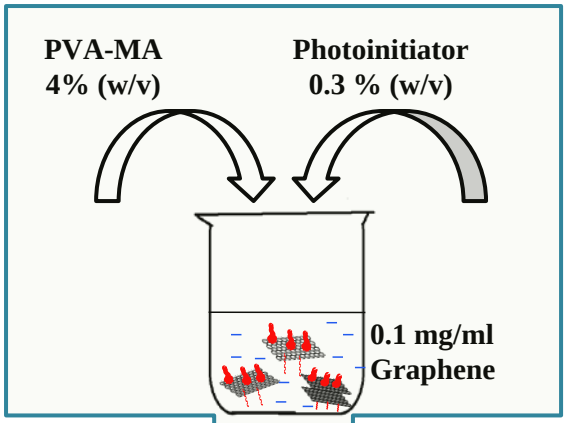



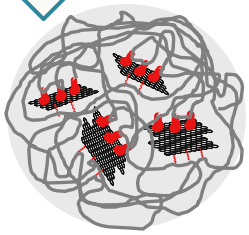

$$y = y_0 + \frac{2A}{\pi}\frac{w}{4(x-xc)^2 + w^2}$$

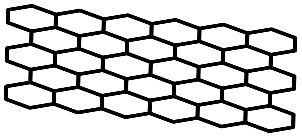


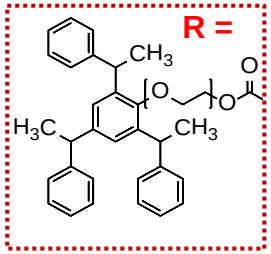

| | Graphite | Graphene |
|---|---|---|
| $I_{2D}/I_G$ | 1.2 ± 0.04 | 3.6 ± 0.03 |
| $I_D/I_G$ | 0.2 ± 0.006 | 0.3 ± 0.016 |
| W ($cm^{-1}$) | 76.9 | 27.0 |

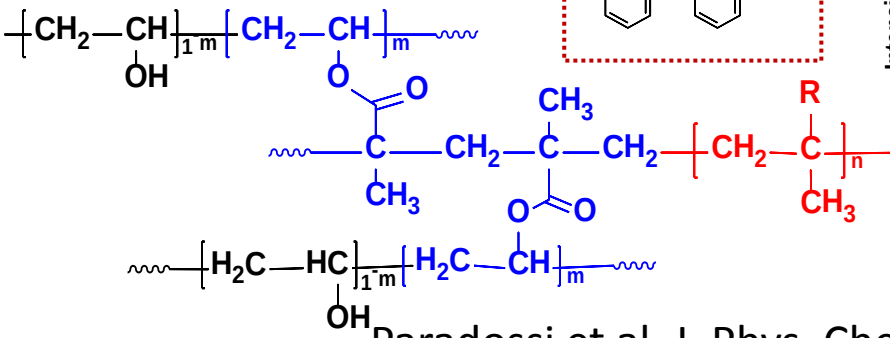
# Pristine Graphene PVA-MA Hybrid Hydrogel

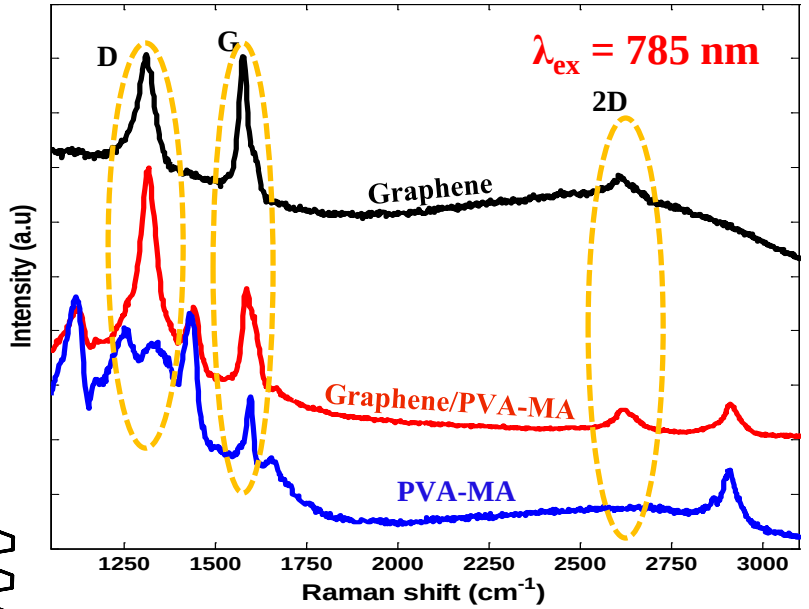


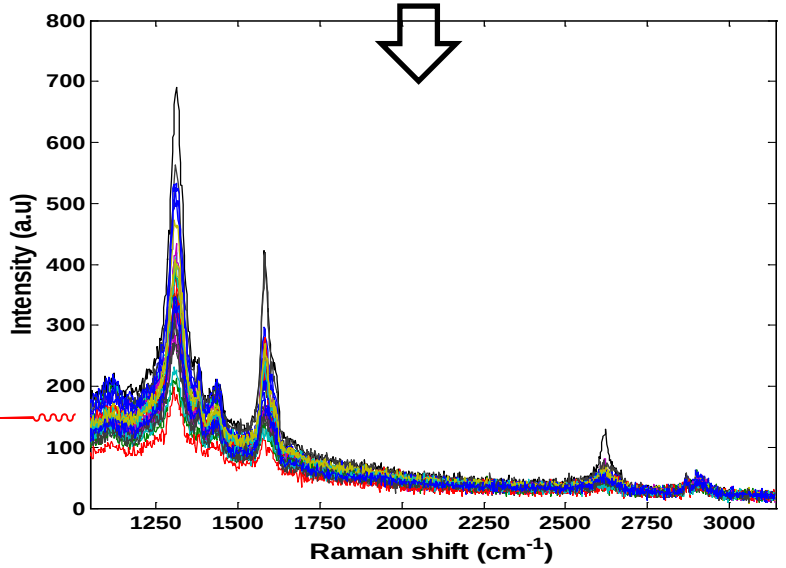







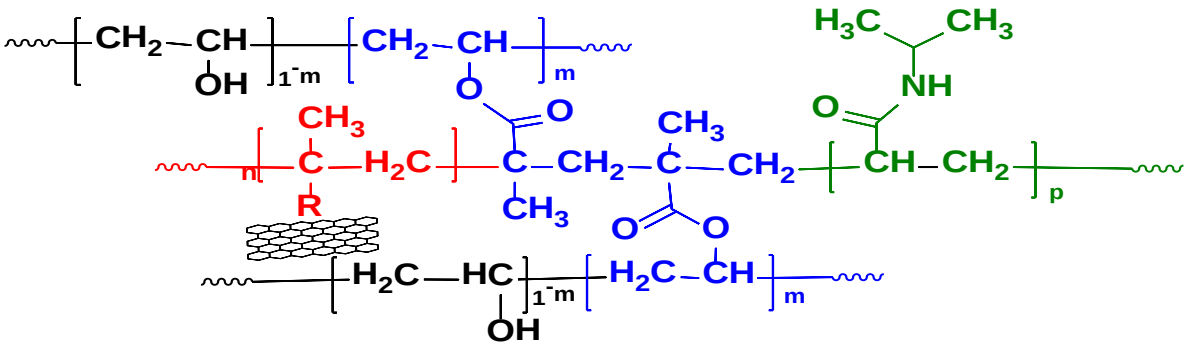



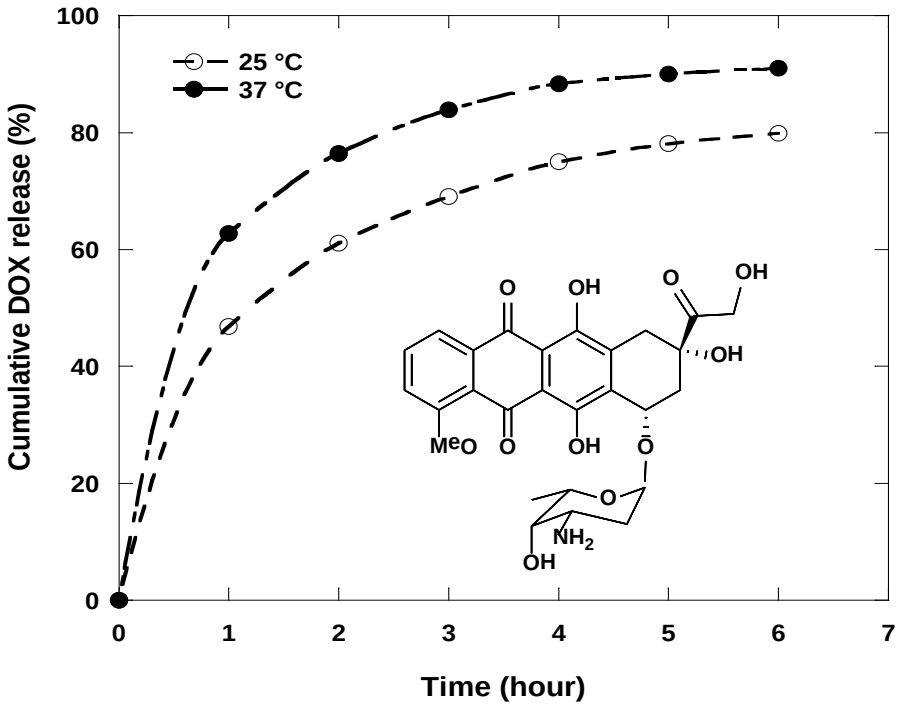



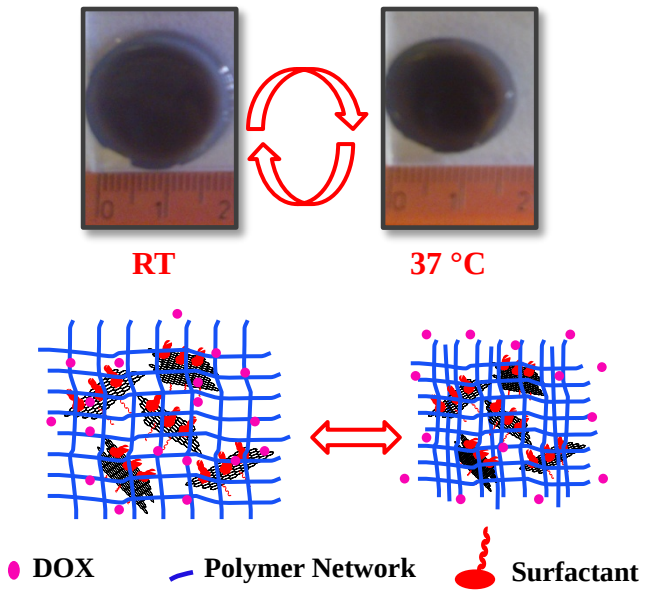




Paradossi et al. J. Phys. Chem. B 2015, 119, 2051−2061

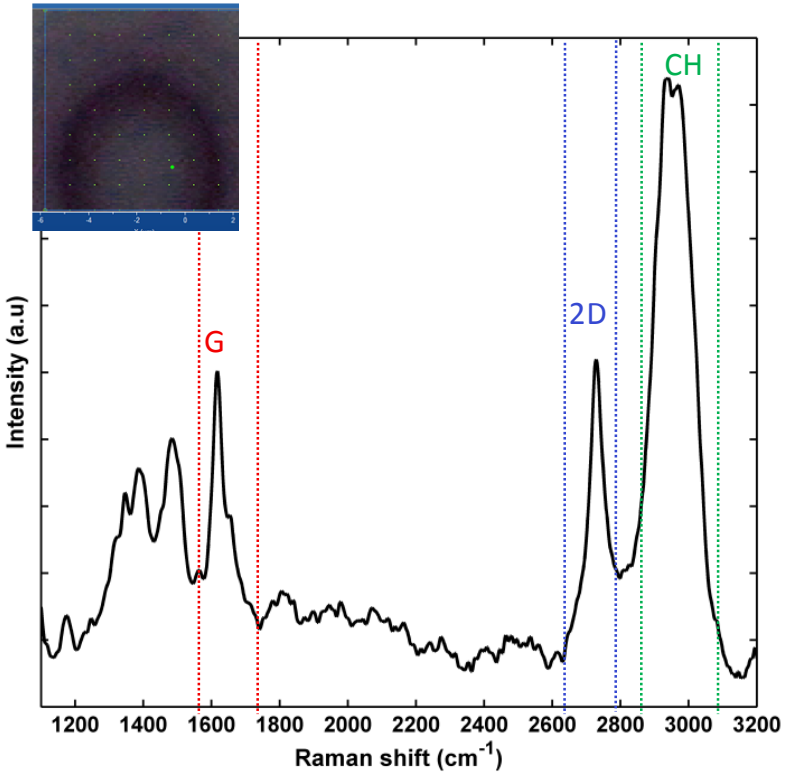
# Thermoresponsive Hydrogel -Doxorubicine Release Kinetics



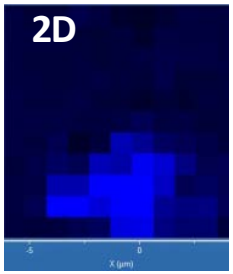


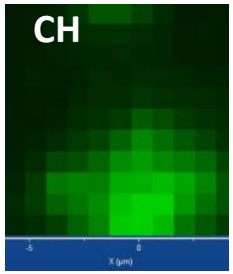



## Confocal Raman Mapping (532 nm)

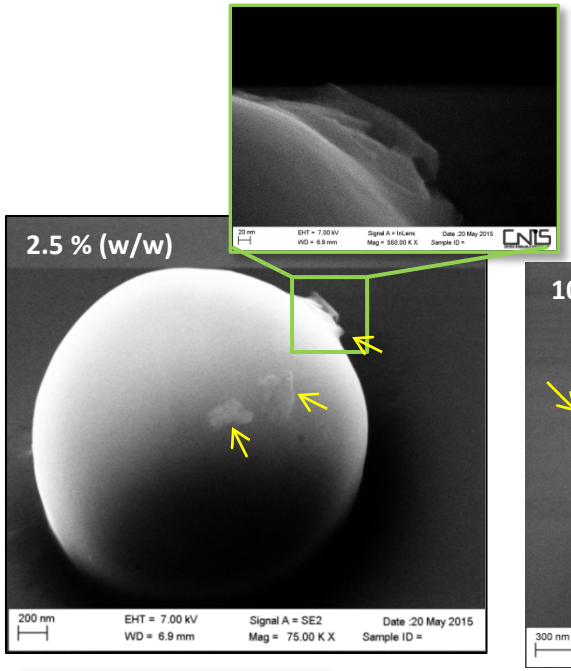


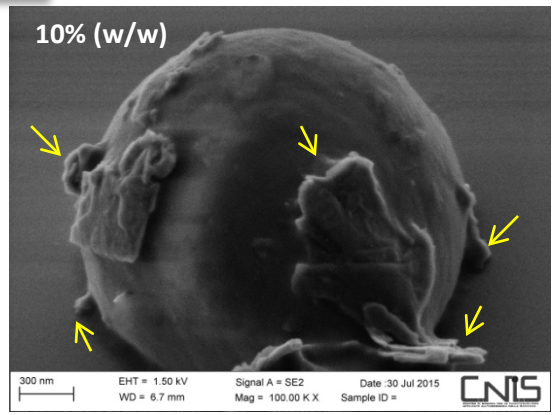


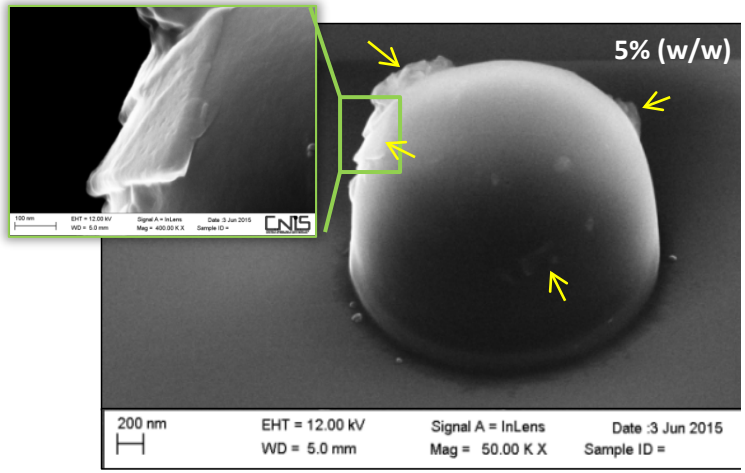



## Field Emission Scanning Electron Microscopy



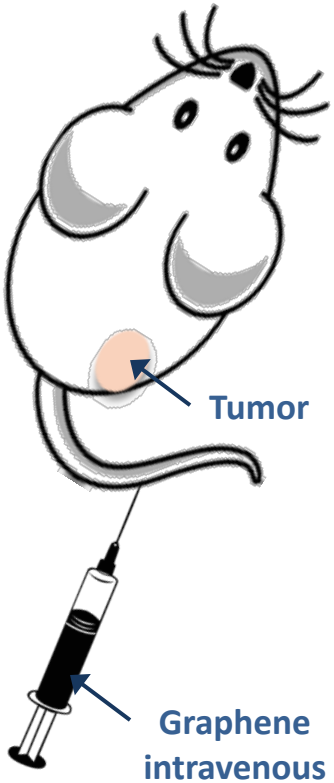



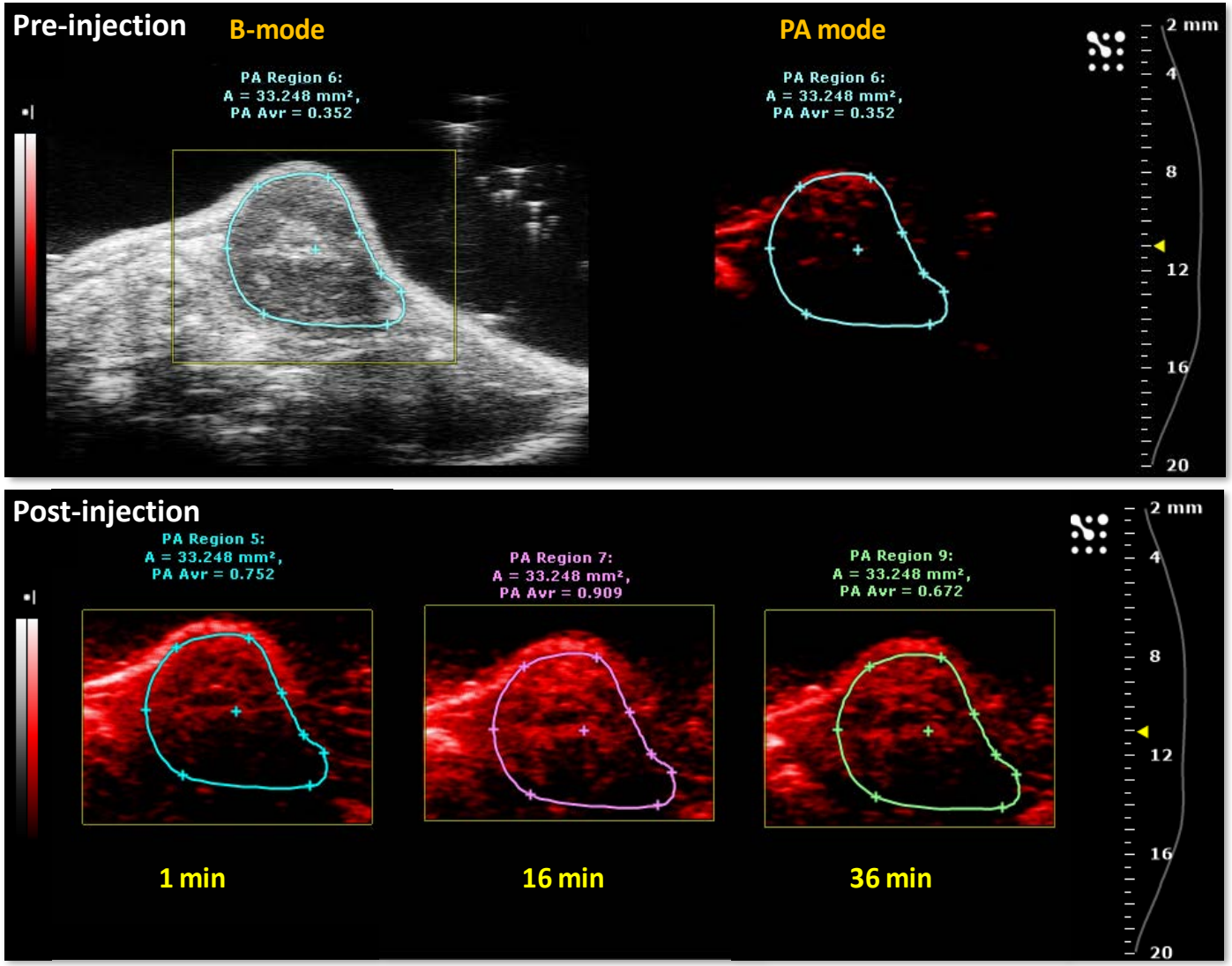




ACS Appl. Mater. Interfaces 2016, 8, 16465−16475

# *In vivo* PAI (Graphene dispersion)

*Balb mouse*

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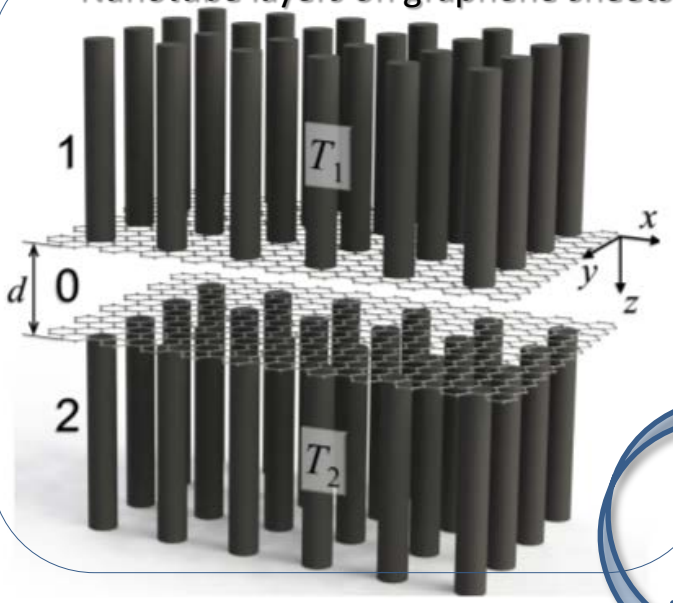
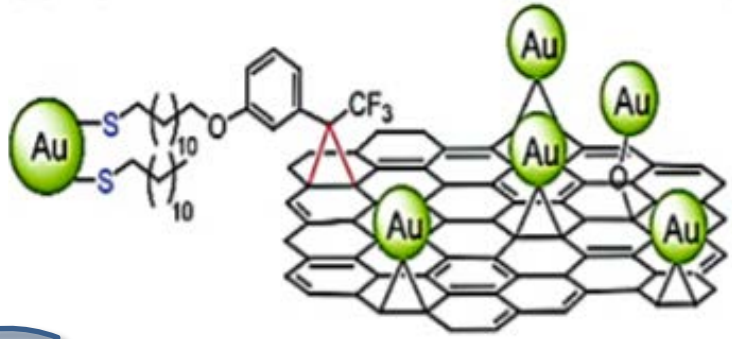
To date, experimental-computational advances have enabled elucidation of near-field radiative heat transfer in gaps as small as 20–30 nanometres, for symplified optical systems only (dipolar approximation).

***The Objective of TRAHND*** *is the theoretical-experimental study of the plasmon-induced anomalous TRH response occurring at the nanoscale distances between different components of the complex hybrid nanomaterial* (graphene, porphyrins, nanotubes, nanoparticle, polymer-np thin film)

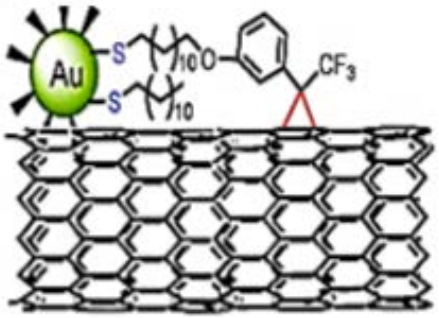
Nanotube layers on graphene sheets




(a) Decoration of AuNPs on graphene

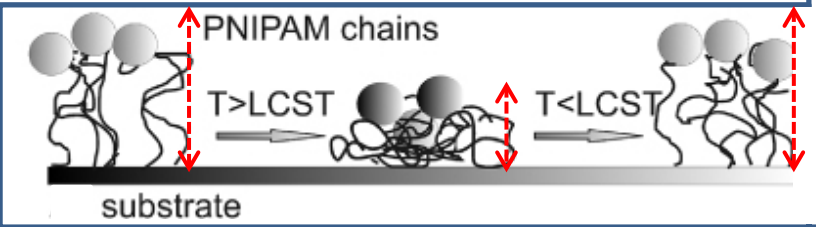


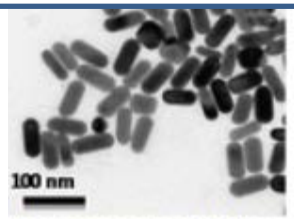

(b) Covalent attachment of AuNP on CNT




*The interaction of Au particles with few layer graphene is of interest for the formation of the next generation of sensing devices*

**Novel thermo-responsive polymeric matrices/scaffolds can switch (reversibly) structural morphologies and interface distances at the nanoscale**




*Au nanoparticles*

+

*PNIPAM*

*New synergies*