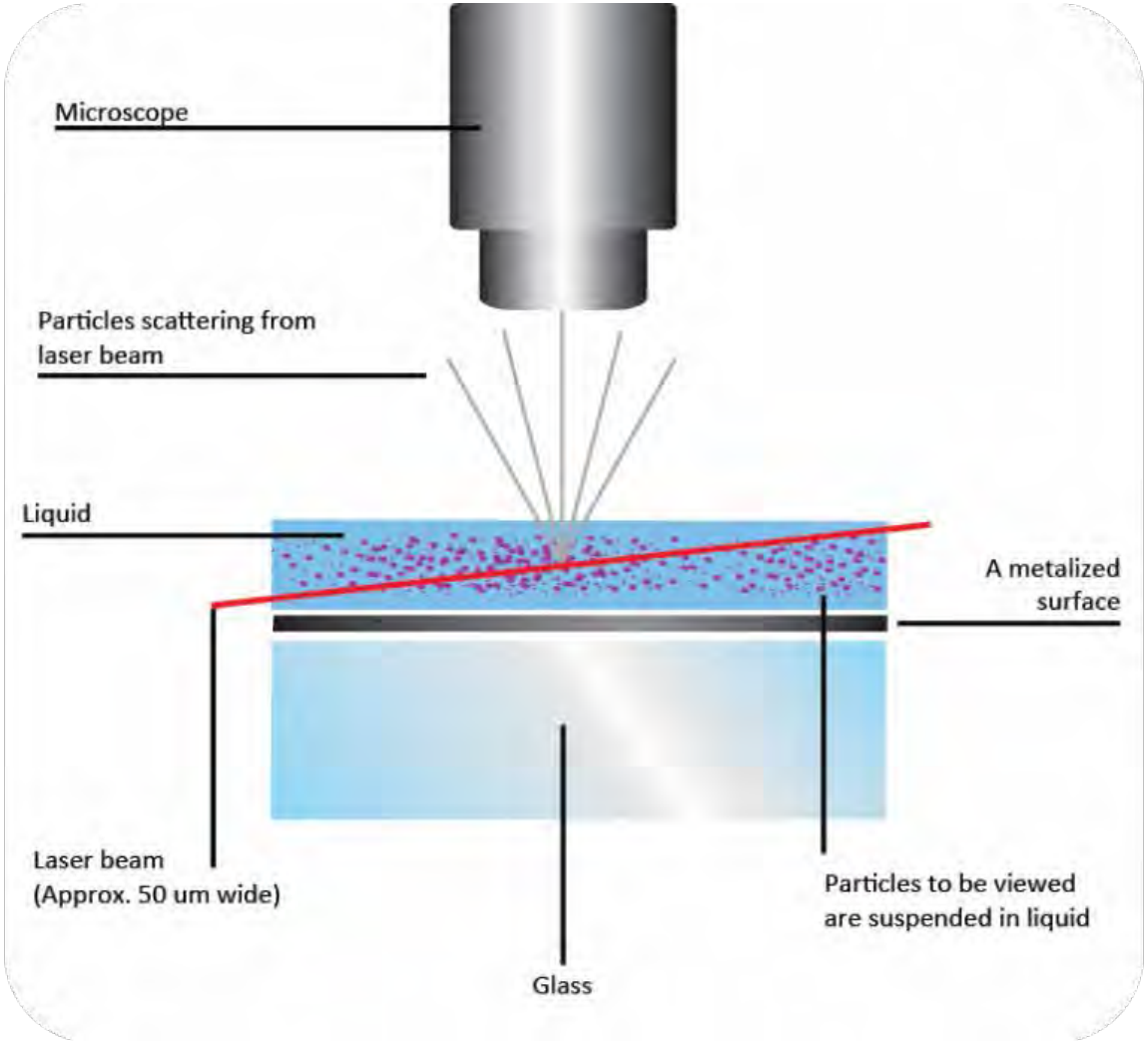
University of Reading

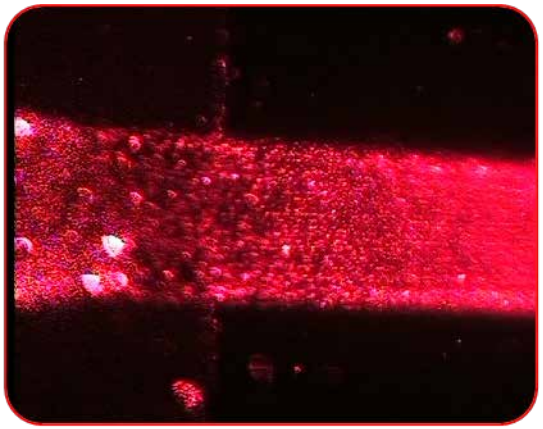
Nanoparticle tracking analysis as a technique for sizing and diffusion studies

Prof Vitaliy Khutoryanskiy

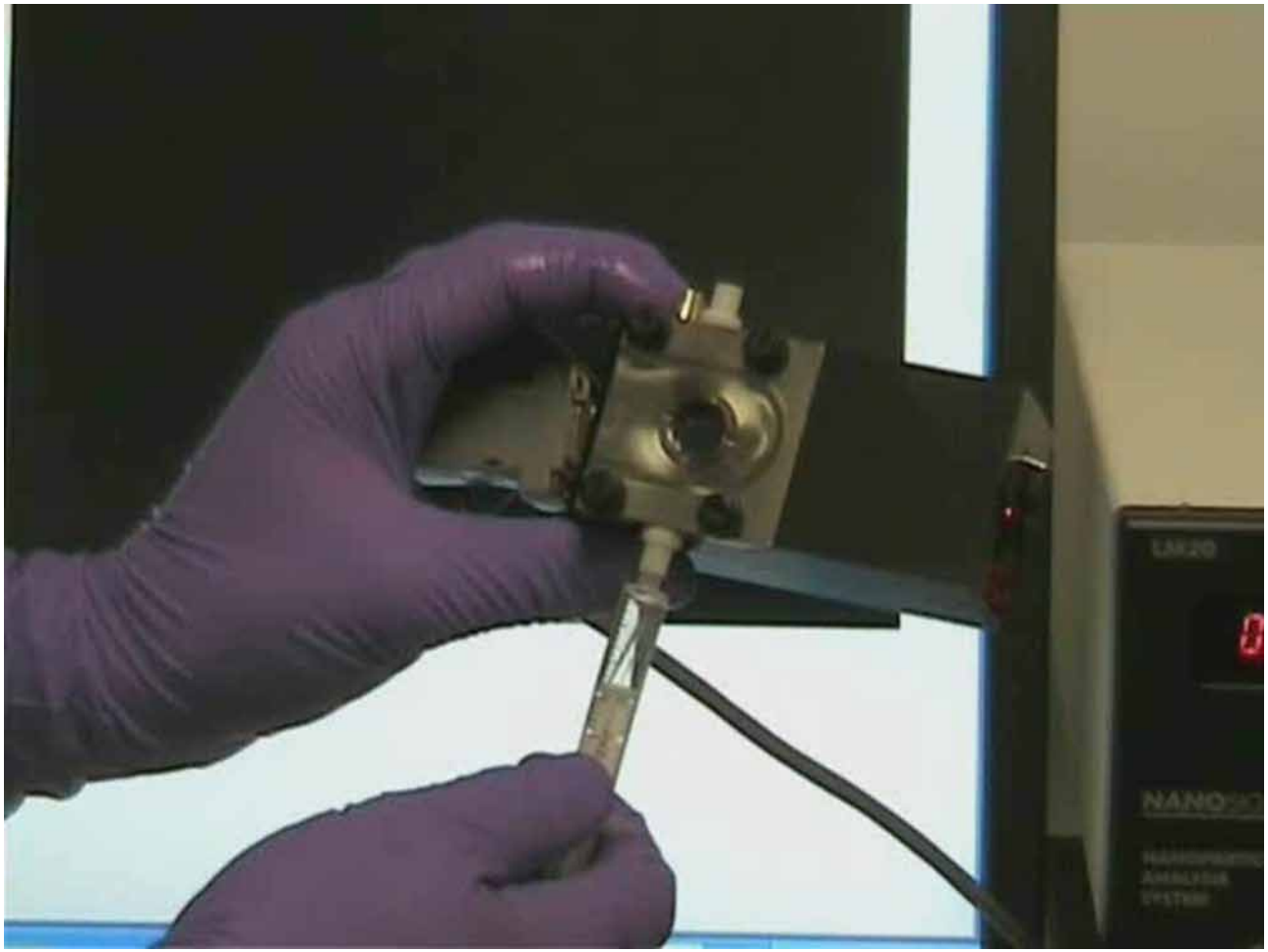
Reading School of Pharmacy
University of Reading, Whiteknights
PO Box 224, RG6 6AD Reading, UK
Tel: +44 (0) 118 378 6119
E-mail: v.khutoryanskiy@reading.ac.uk

NanoSight's Technology





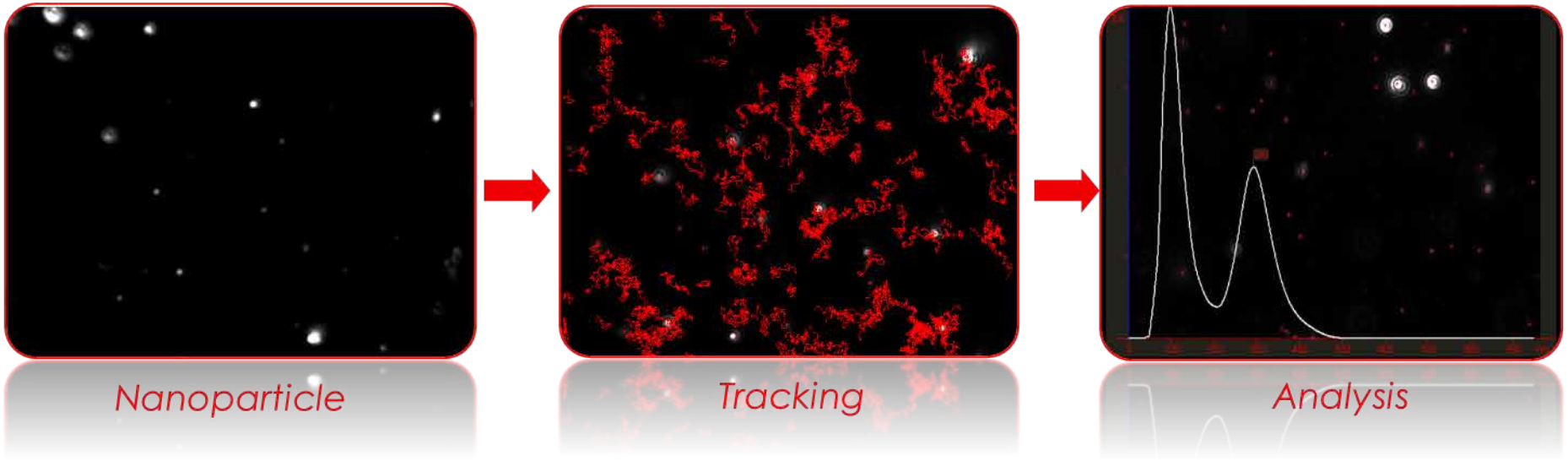
Practical aspects



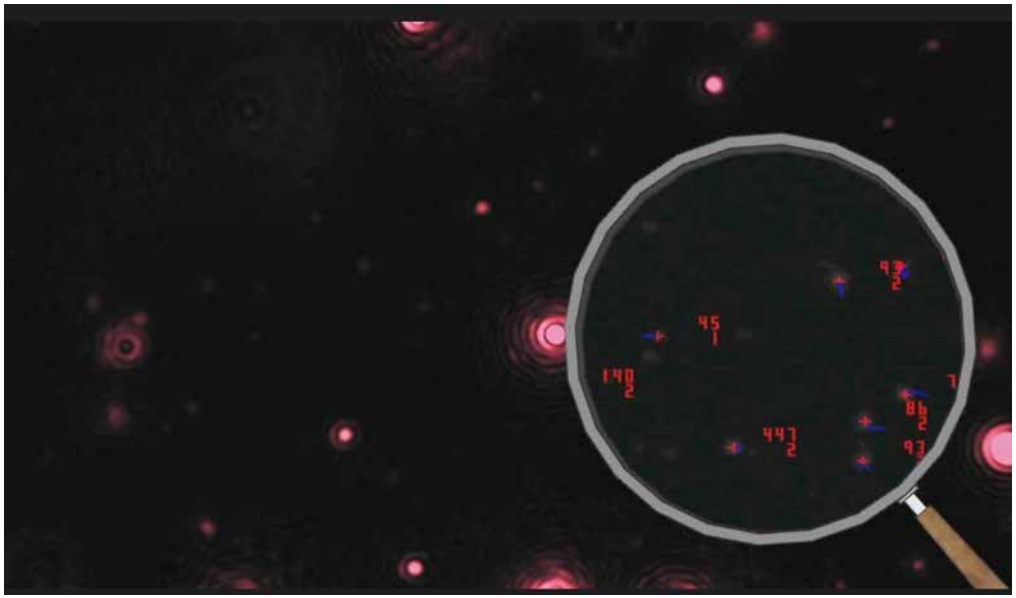
- Load sample
- Insert cell
- Observe nanoparticles

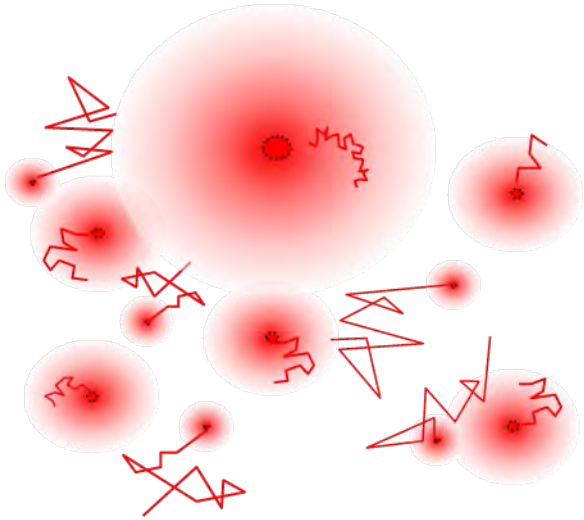
Nanoparticle Tracking Analysis

Nanoparticle Tracking Analysis (**NTA**) measures particle size by video analysis of the Brownian motion, simultaneously, of many individual particles.



Principle of measurements





Temperature

Boltzmann constant

$$D = \frac{kT}{6\pi\eta R}$$

Diffusion coefficient

Particle radius

Viscosity

NTA instruments

LM10 Series

LM 20

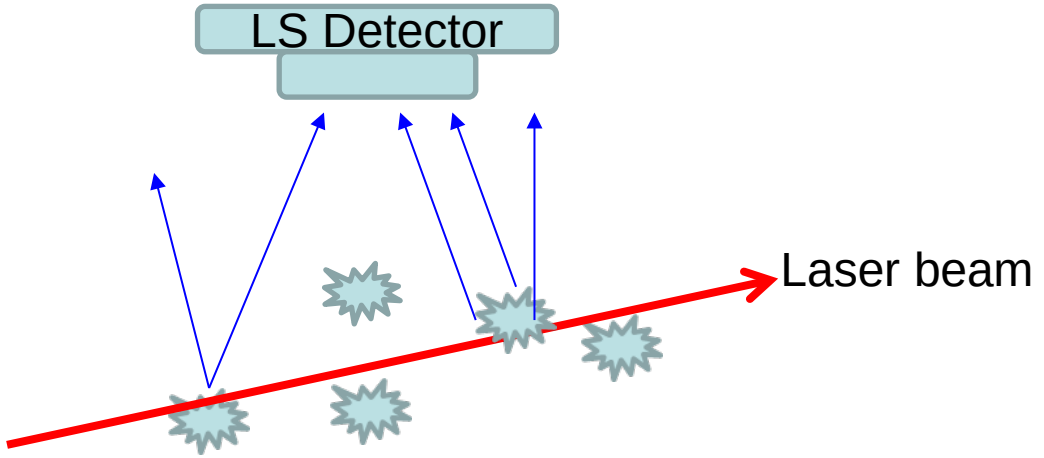
NS 500

Information

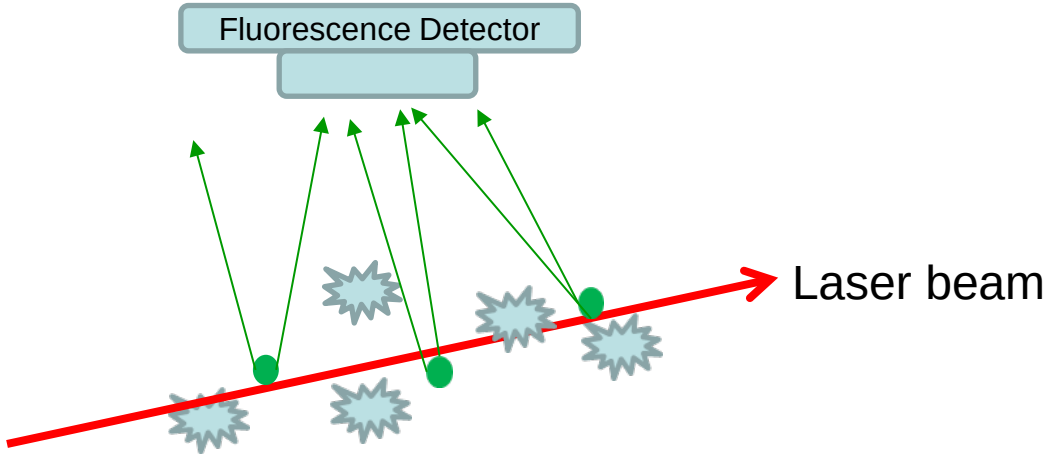
- Particle size distribution of high resolution;
- Particle concentration;
- Diffusion characteristics

Light scattering vs fluorescence mode

- Light scattering detector



- Fluorescence detector

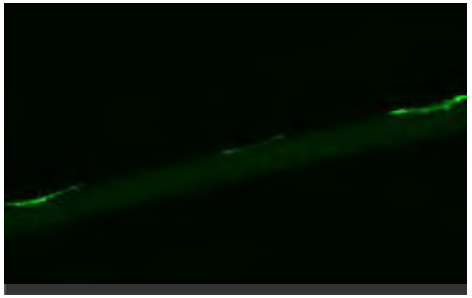


Diffusion of nanomaterials in liquid media

Paint and coating industry: interactions, aggregation and sedimentation of particles

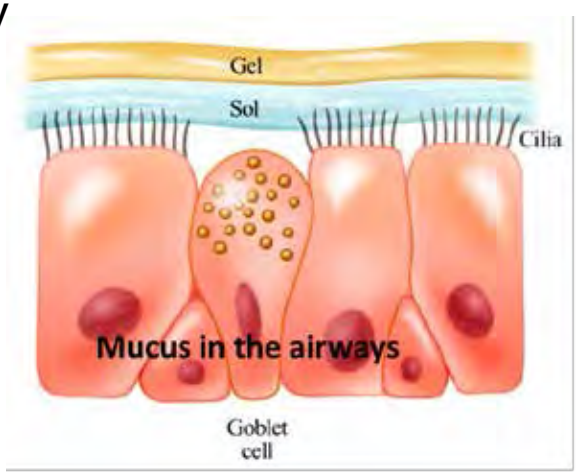
Ind Lubric Tribol 62, 111 (2010)

Cosmetics: particles deposition onto hair and skin surfaces

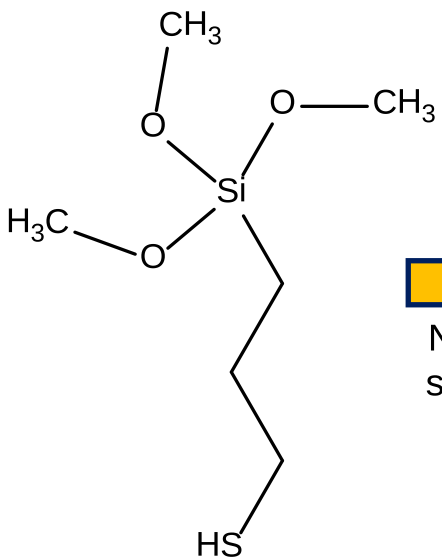


In biological systems: penetration of viruses and bacteria into the body, e.g. in the airway, the mucus gel traps microorganisms that are then eliminated through mucociliary clearance

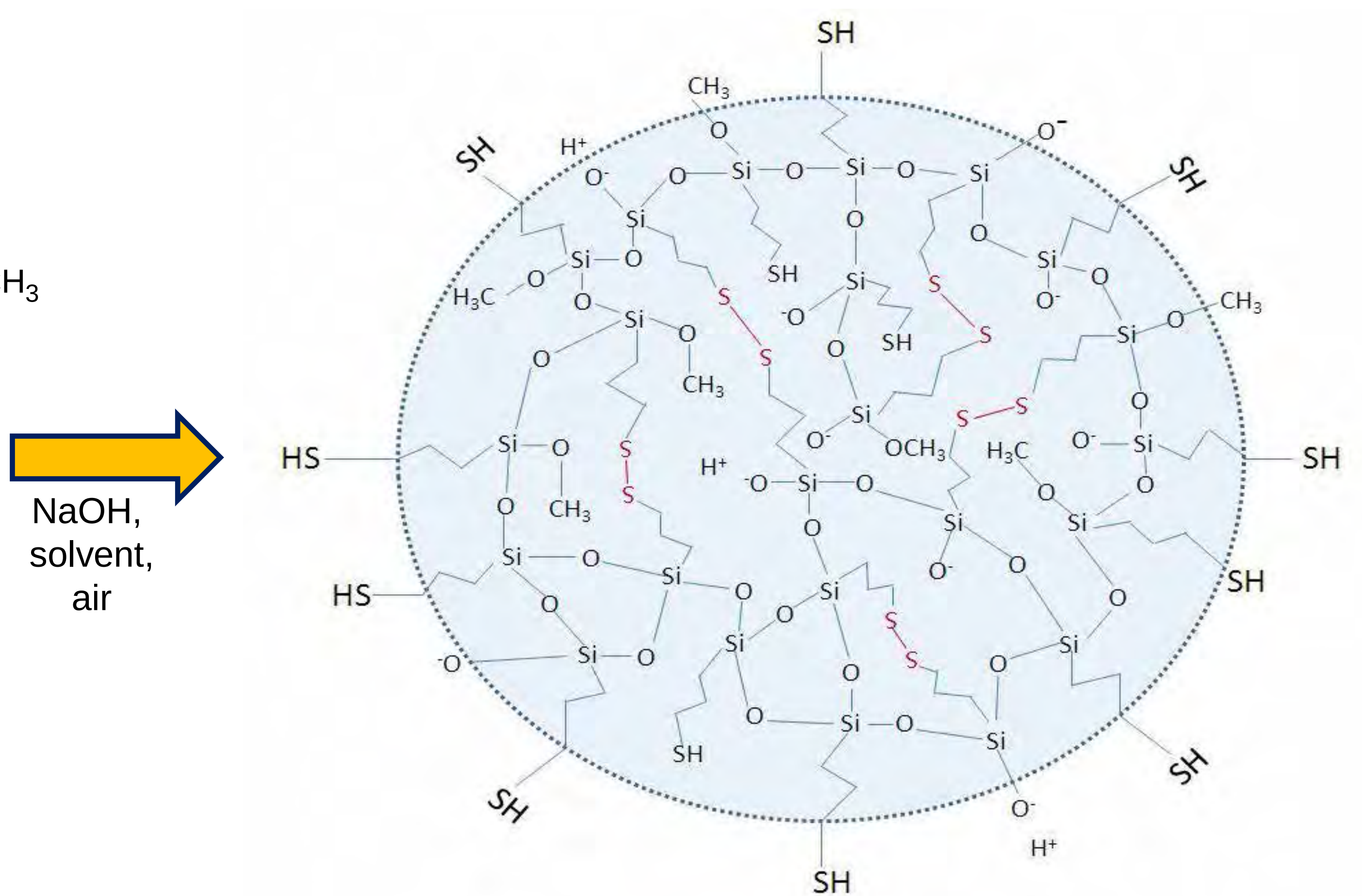
In pharmaceutics: the diffusion of drug molecules and nanomedicines through epithelial mucus gel is important for efficient drug delivery



Thiolated silica nanoparticles as a model system

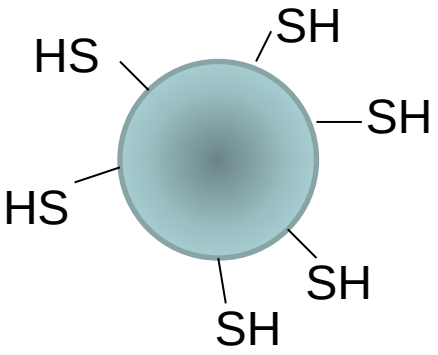


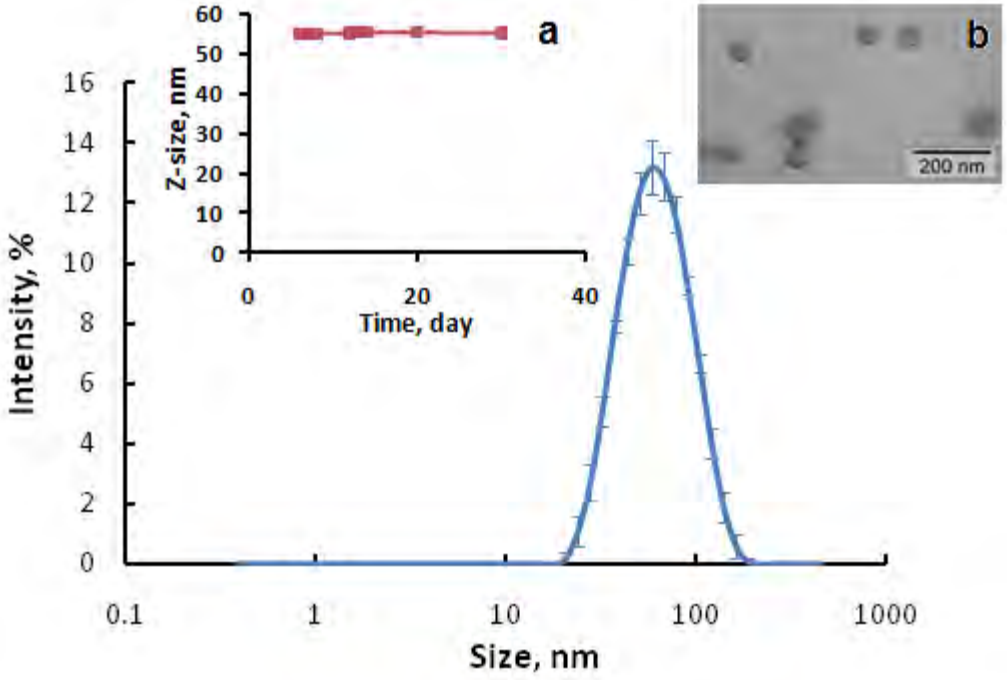
MPTS

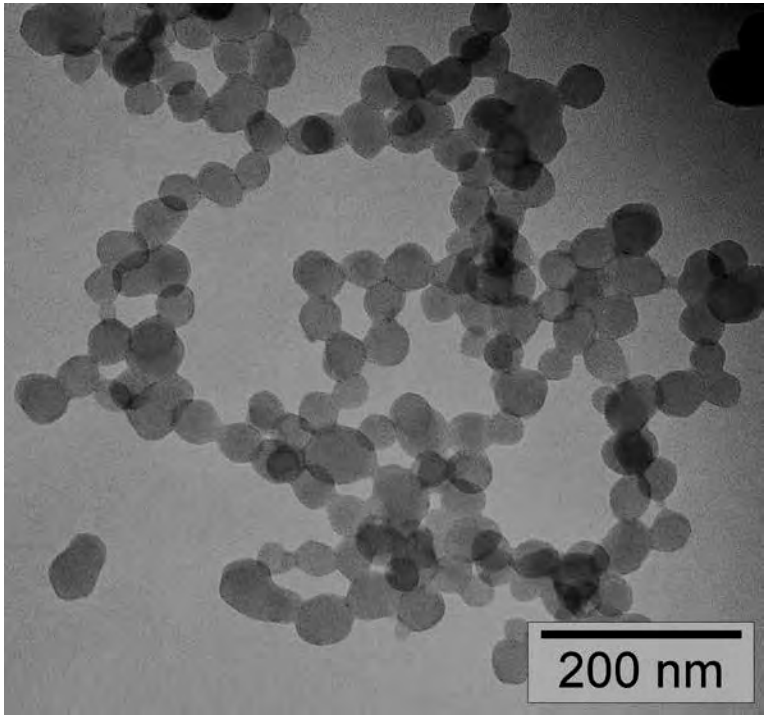


Langmuir **27**, 9551-9556 (2011)

DLS and TEM

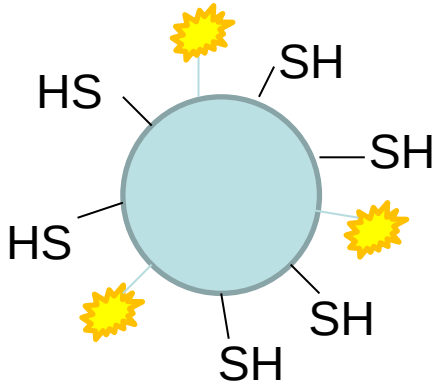


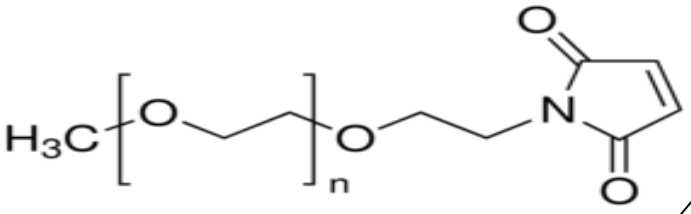




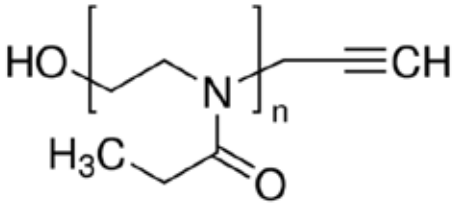
Langmuir, 27, 9551-9556 (2011)

Surface functionalisation

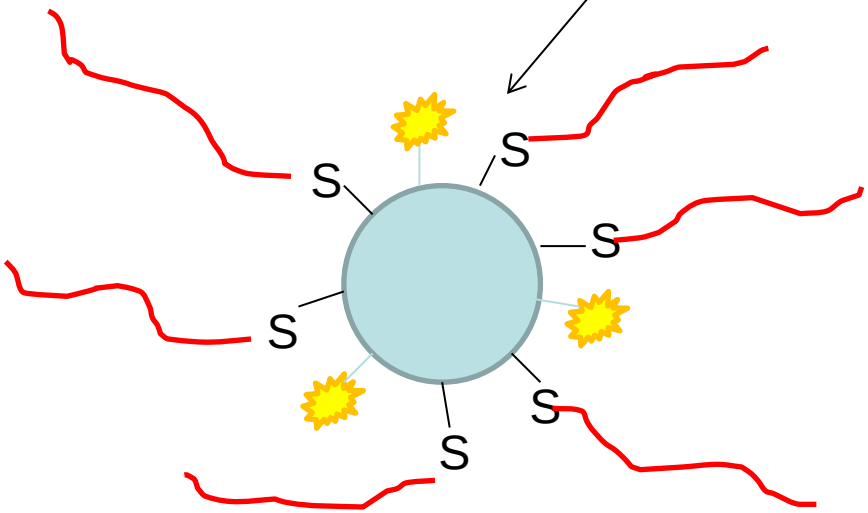


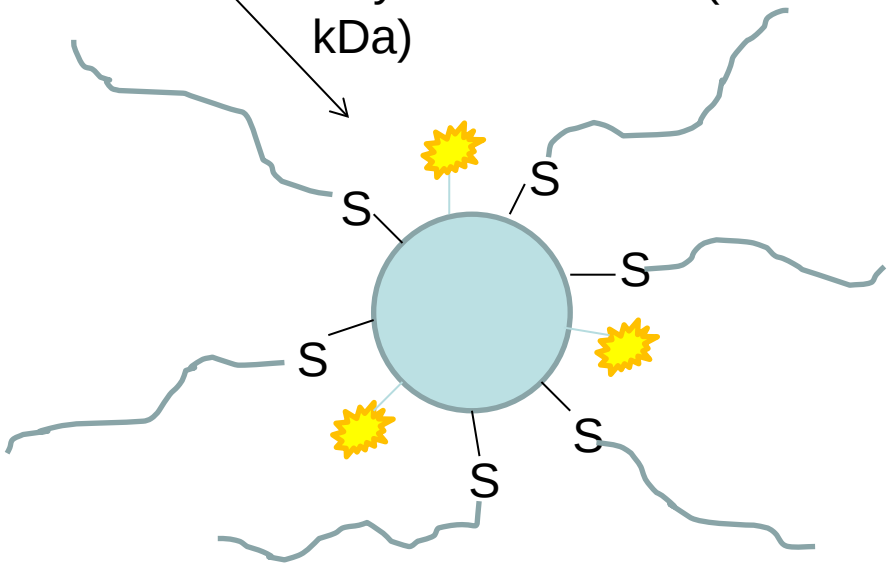


PEG maleimide
(5 kDa)

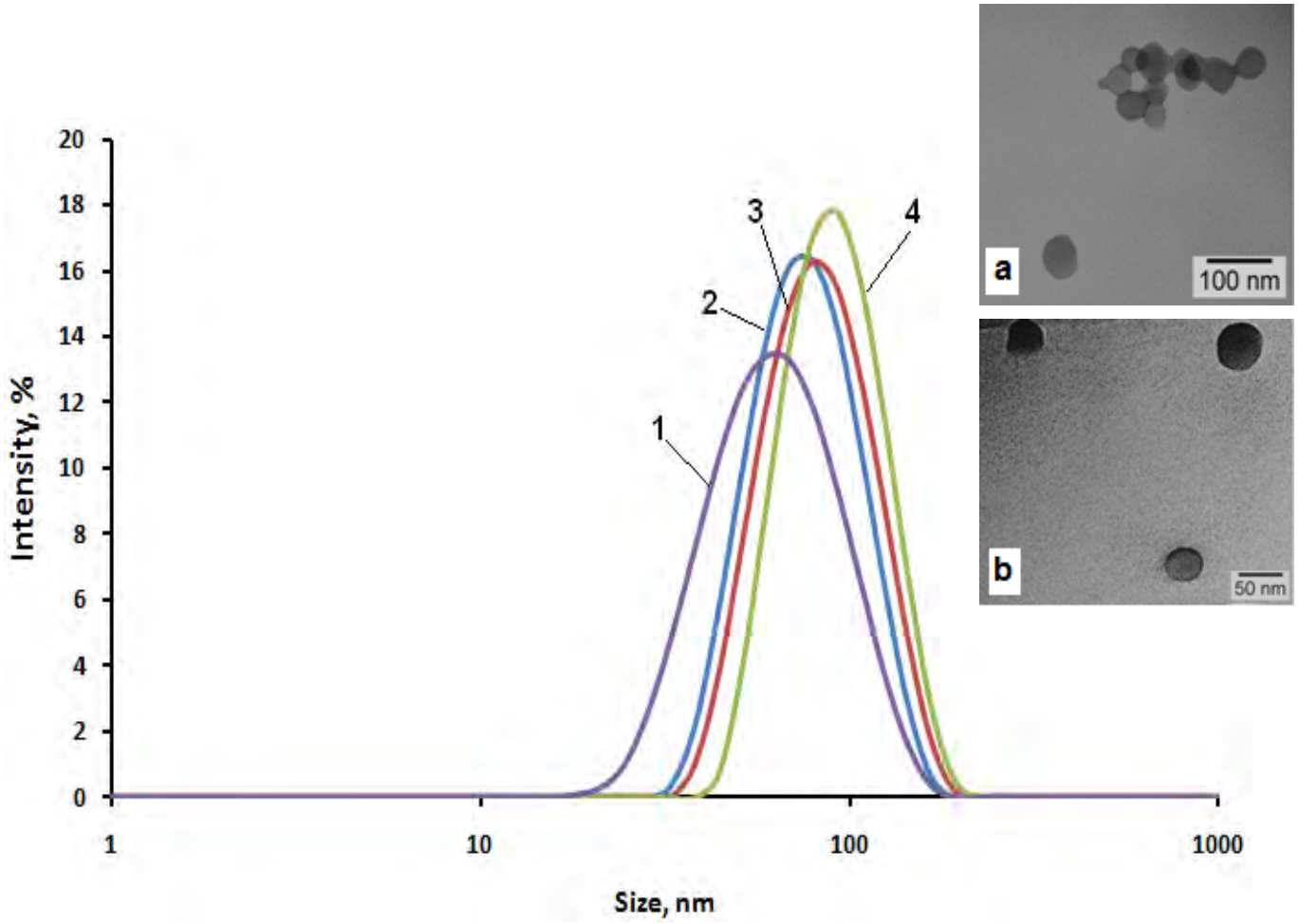


Poly(2-ethyl-2-oxazoline), alkyne terminated (5 kDa)





Sizes of nanoparticles before (1) and after PEGylation (2-4)

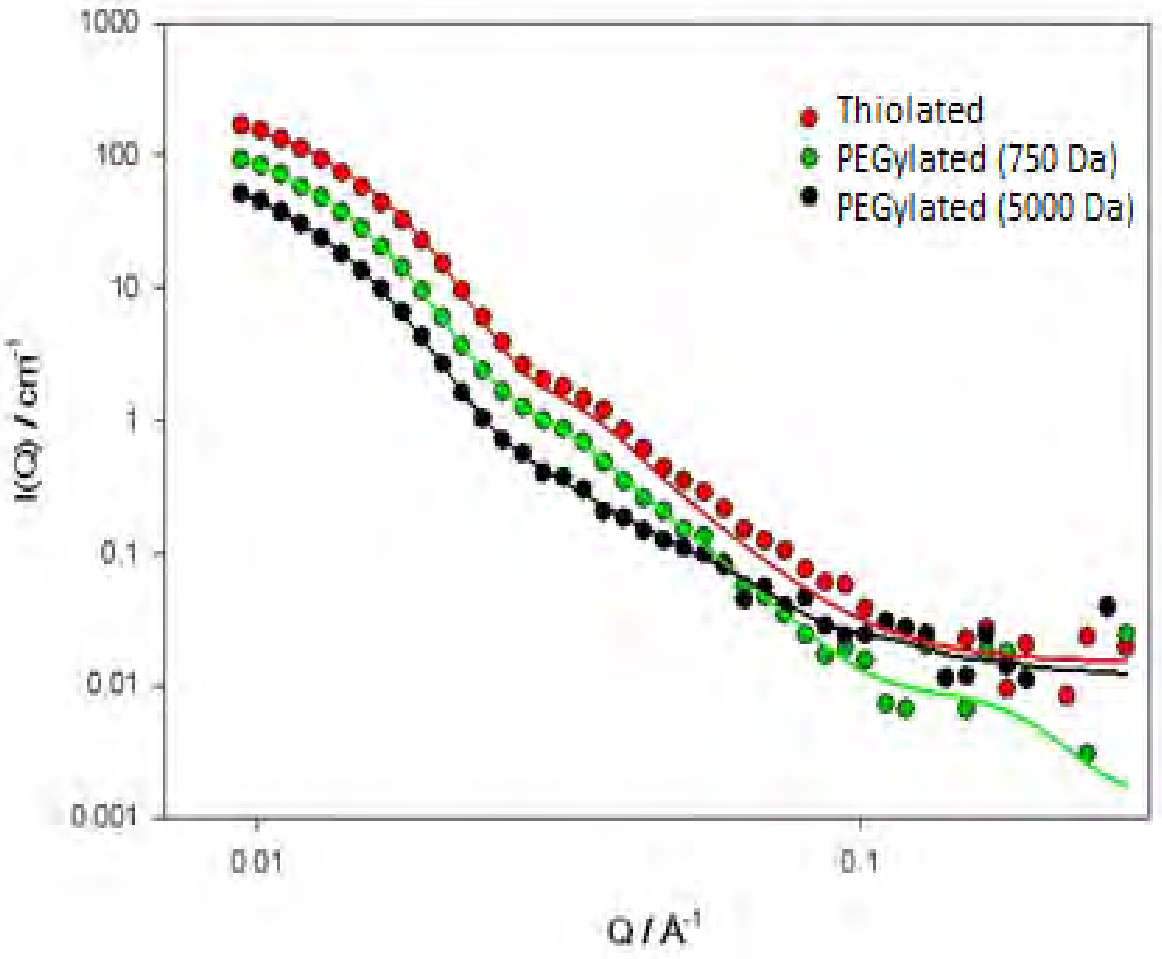


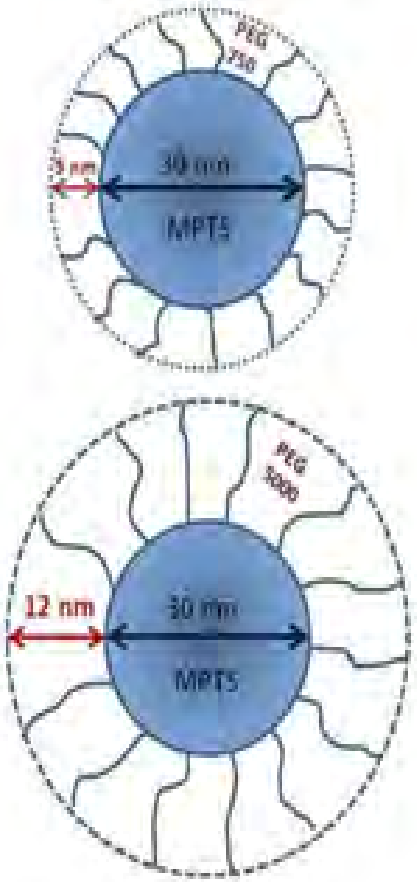
Thiolated NPs

PEGylated NPs

Langmuir **28**, 299–306 (2012)

Small angle neutron scattering

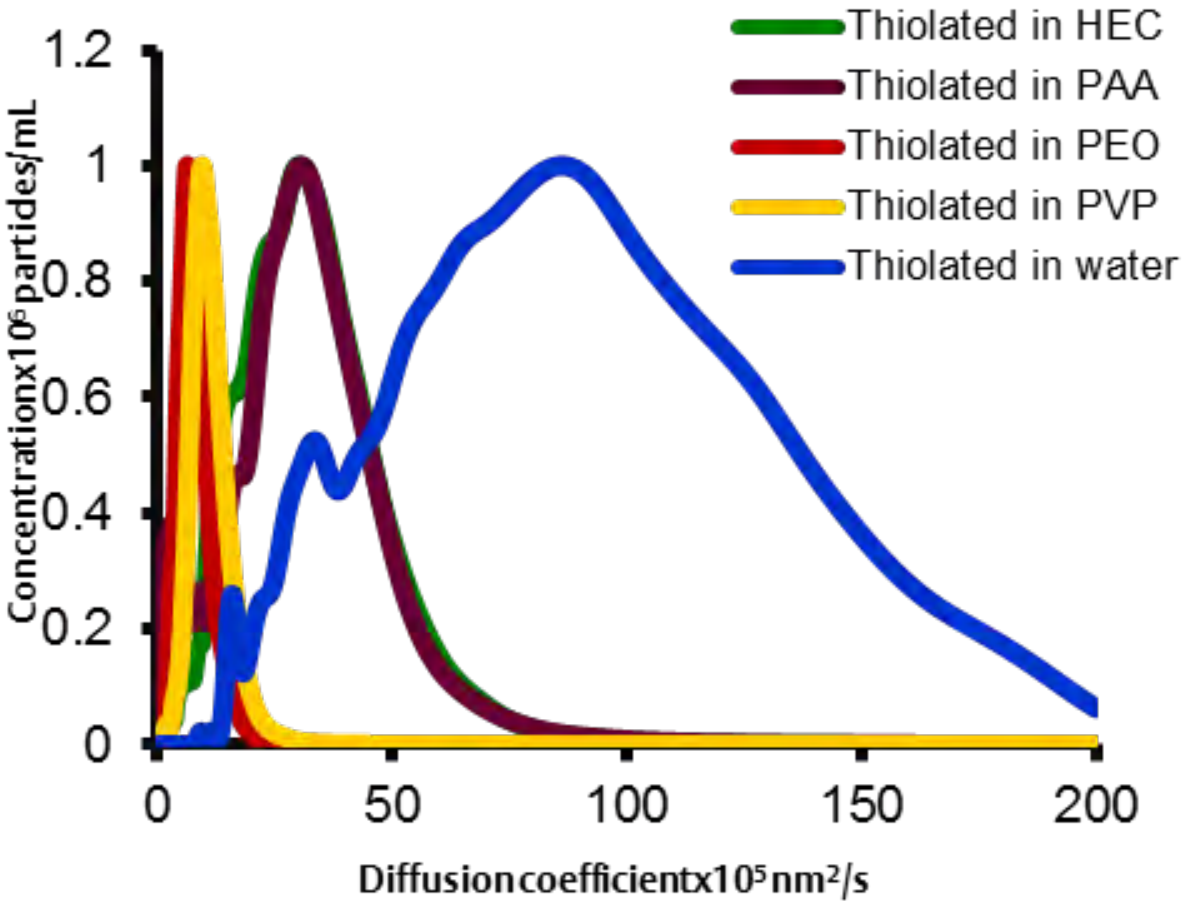




Collaboration with Dr Sarah Rogers (ISIS)

Langmuir, **30**, 308–317(2014)

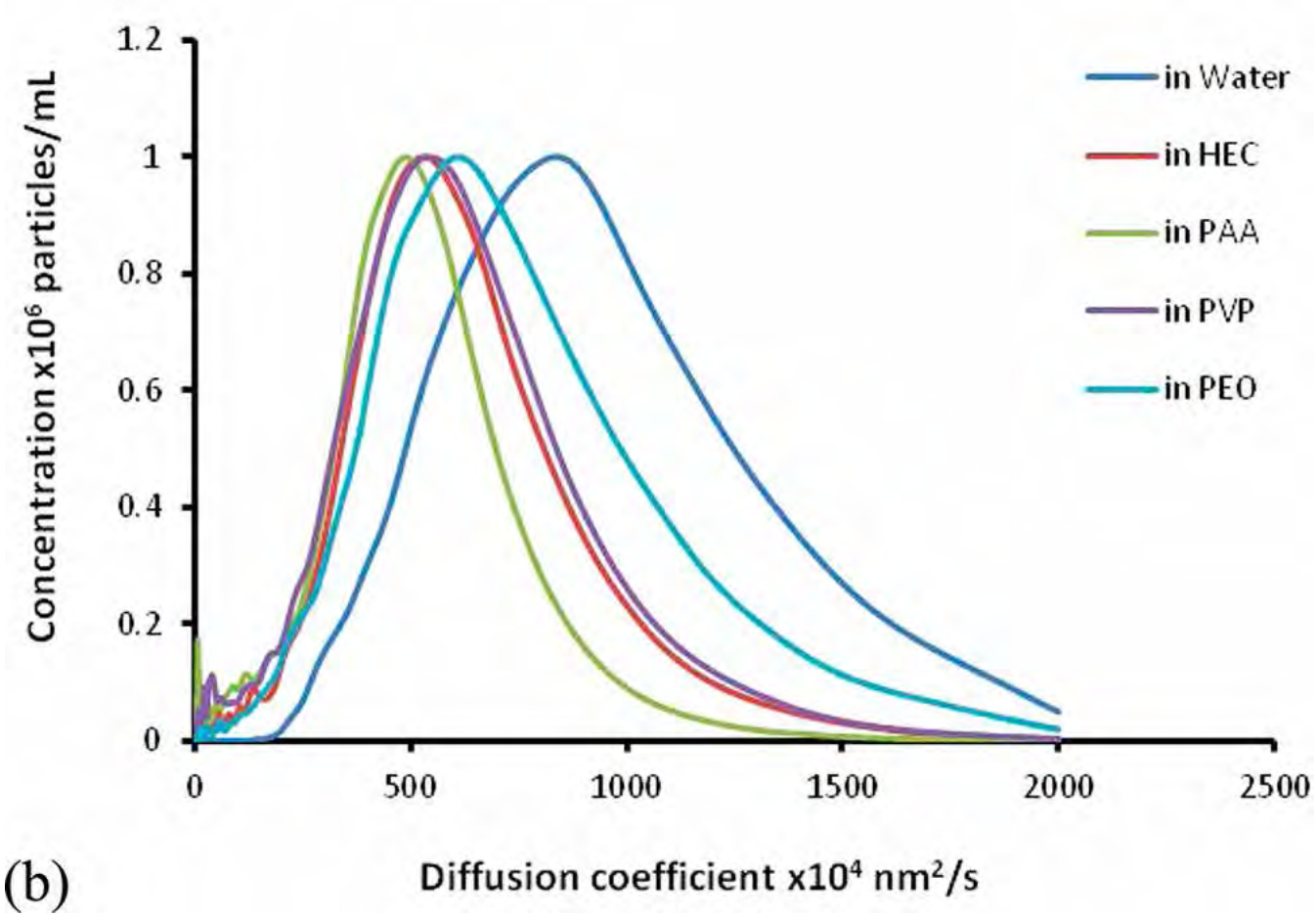
Diffusion of thiolated silica in polymer solutions



Slower diffusion is observed in PEO and PVP

Langmuir, 30, 308 (2014)

Diffusion of PEGylated silica in polymer solutions

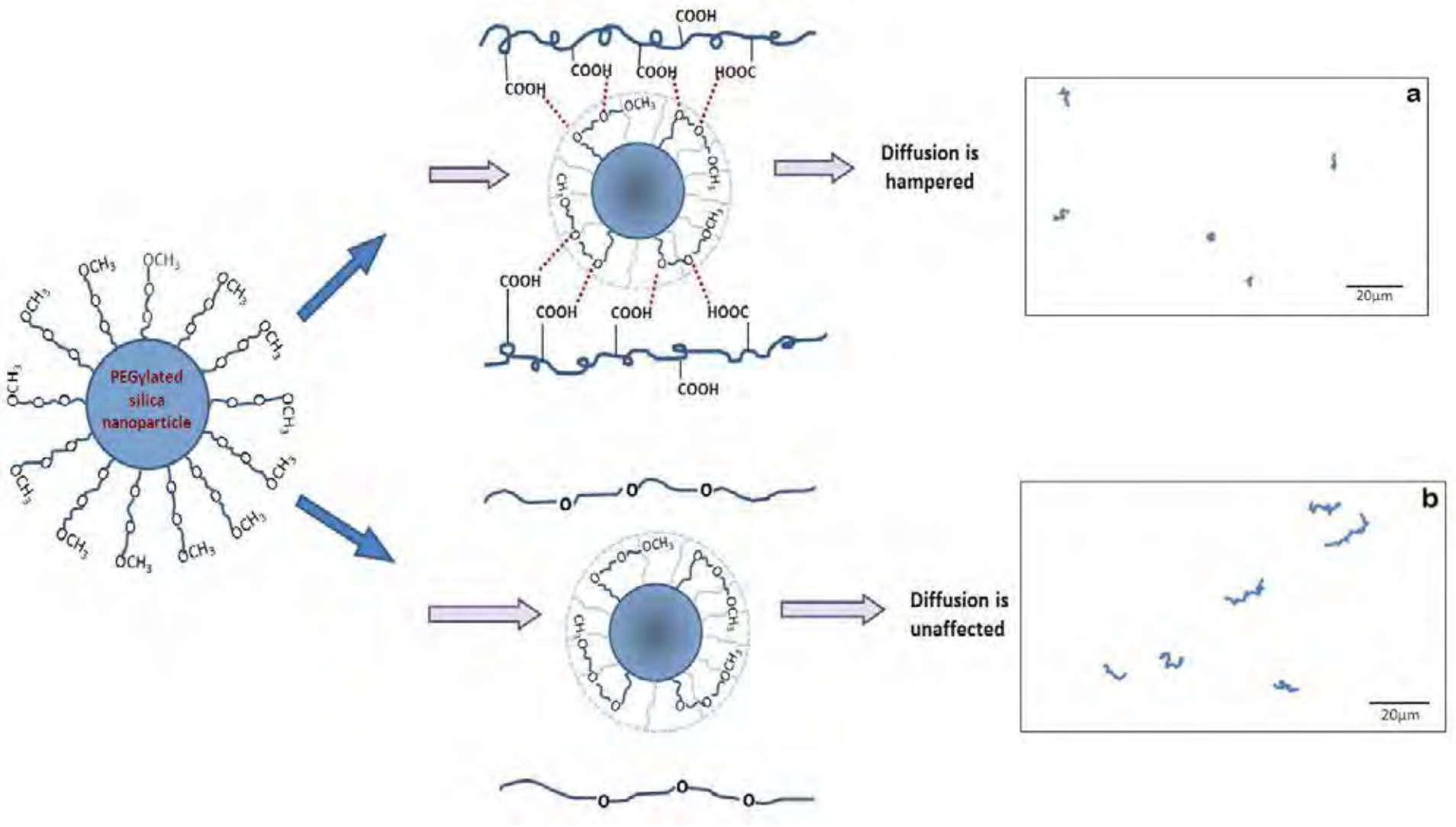


(b)

Slower diffusion is observed in PAA

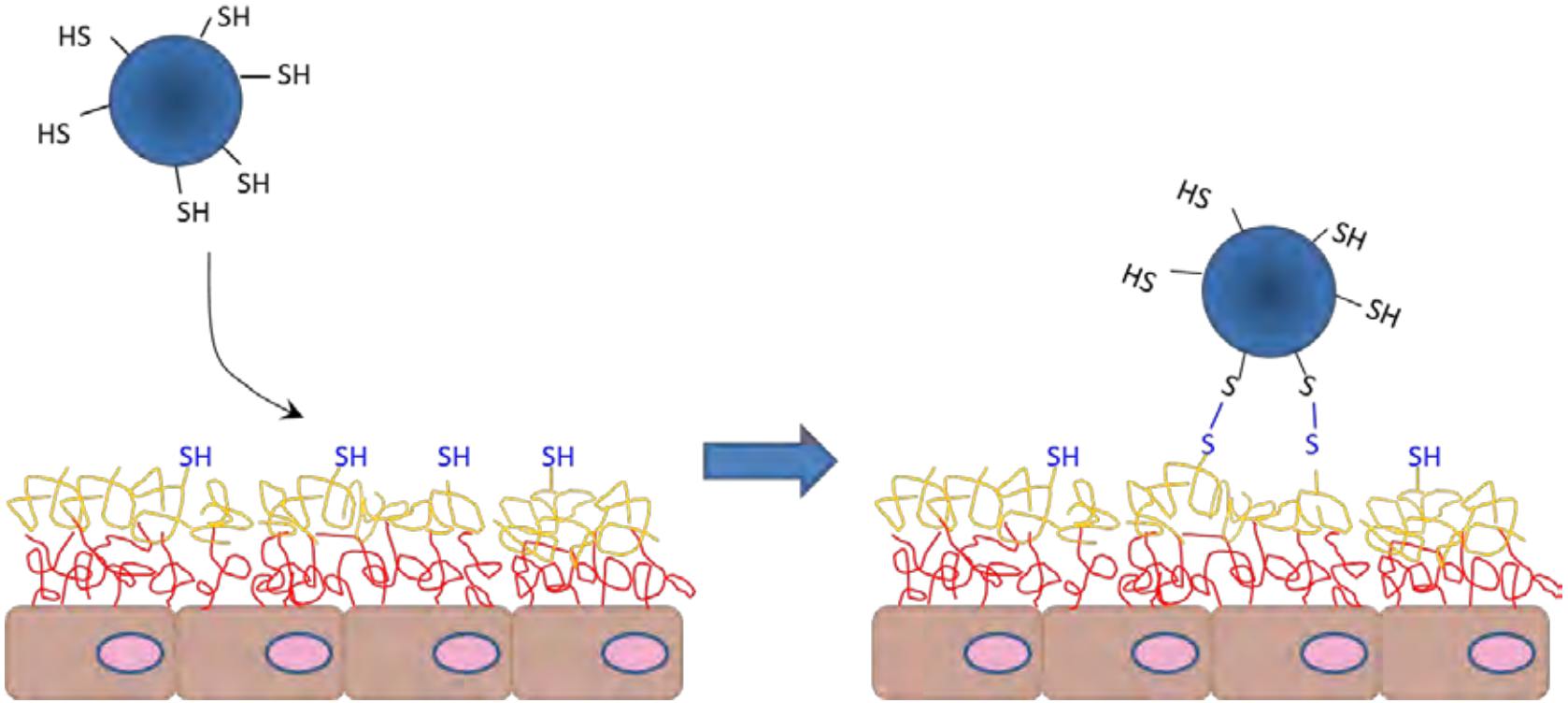
Langmuir, 30, 308–317(2014)

Effect of interactions on diffusion

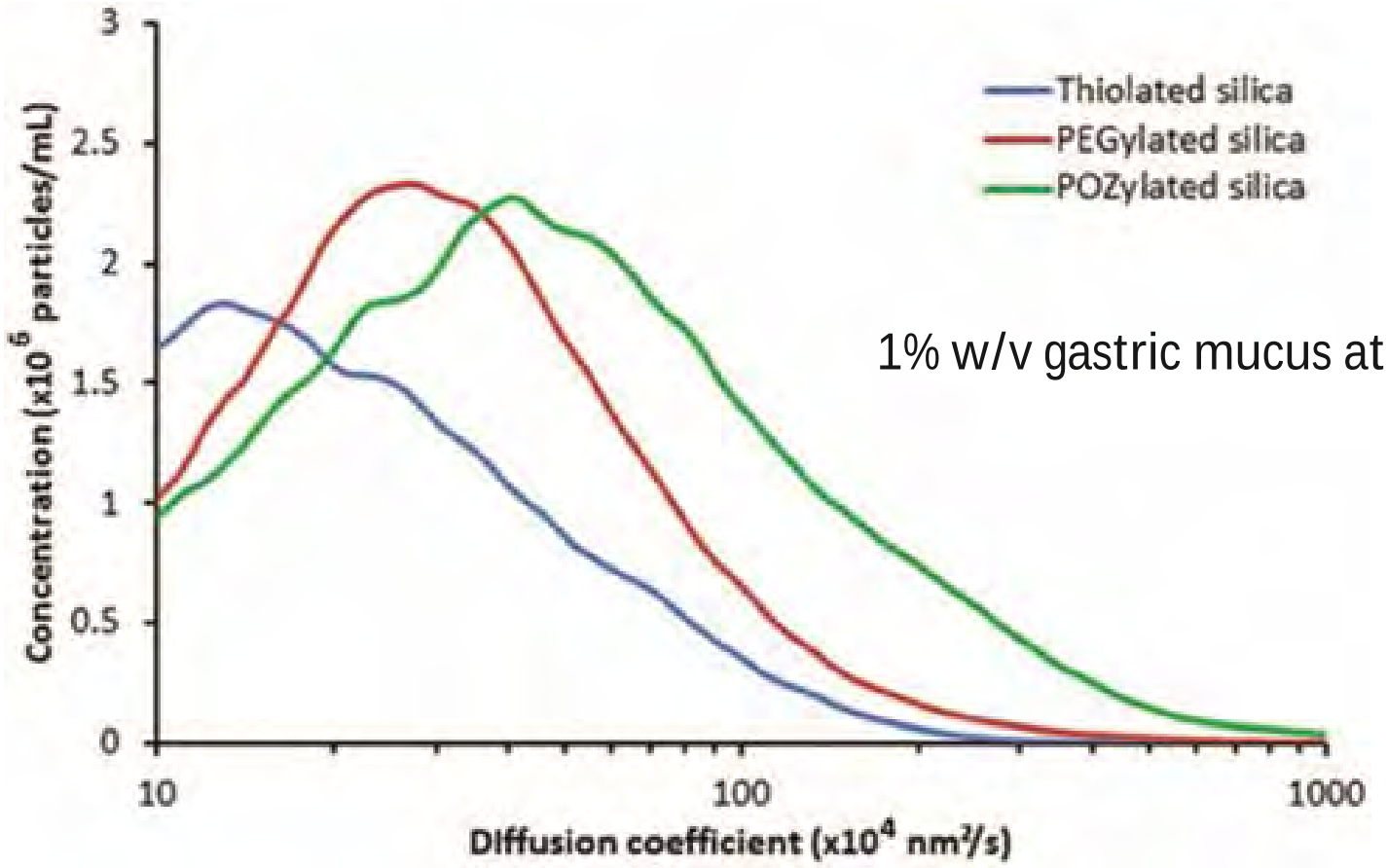


Langmuir, 30, 308–317(2014)

Mucosal adhesion and penetration of nanoparticles



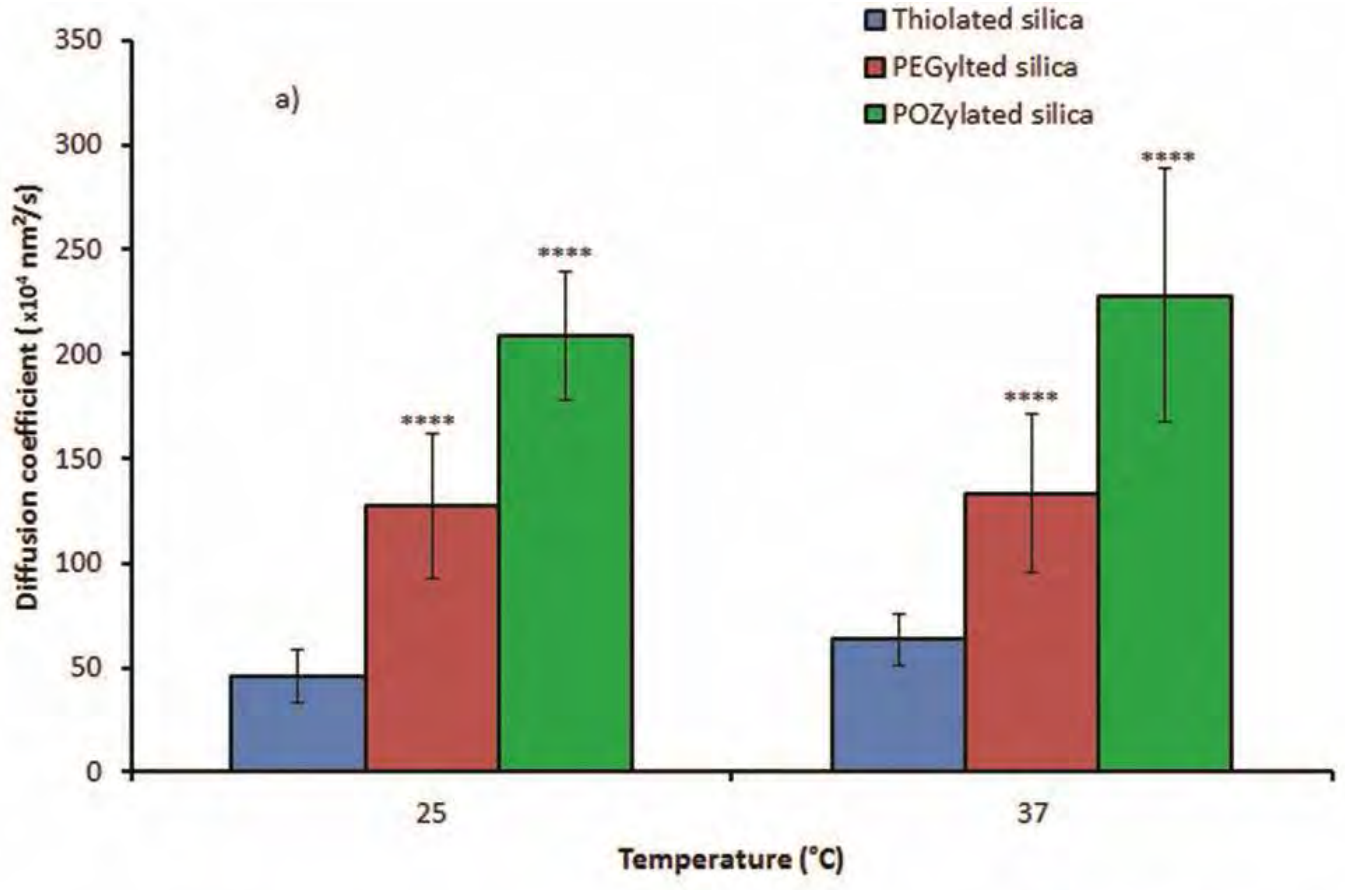
Diffusion of nanoparticles in porcine gastric mucin dispersions



1% w/v gastric mucus at 37 °C

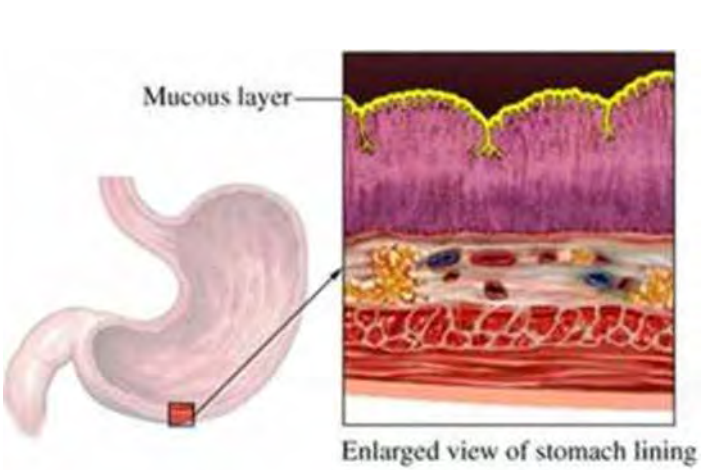
Nanoscale, 7, 13671 (2015)

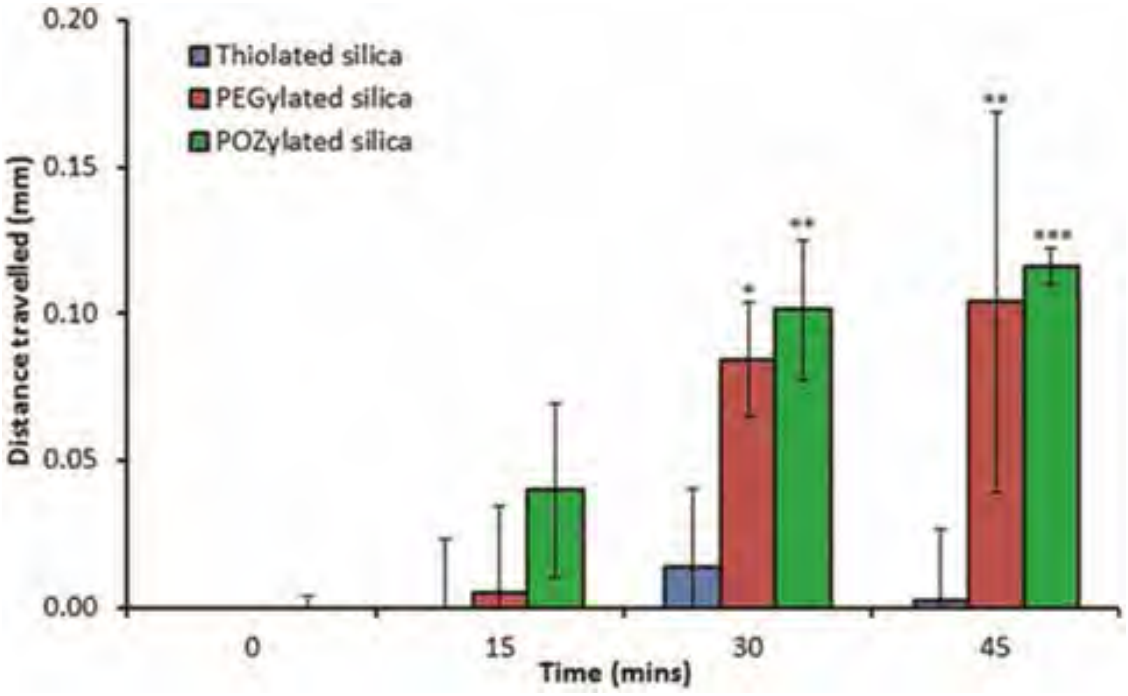
Diffusion coefficients at different temperatures



Nanoscale, 7, 13671 (2015)

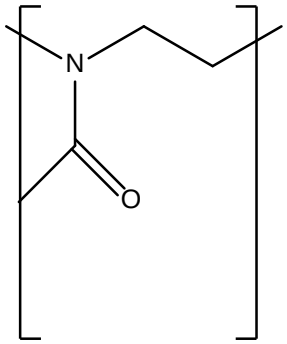
Permeation of nanoparticles through freshly excised porcine gastric mucosa



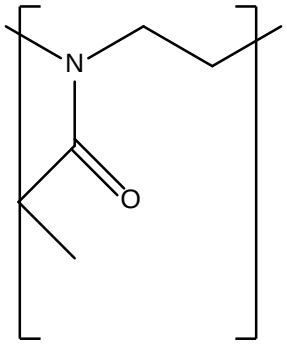


Nanoscale, 7, 13671 (2015)

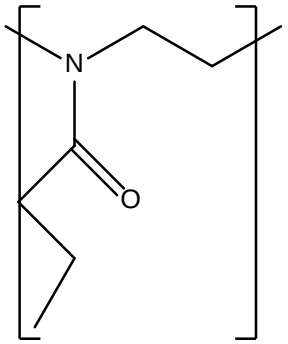
Nanoparticles functionalised with different alkyne terminated poly(2-alkyl-2-oxazolines



Methyl-POZ
(PMOZ)



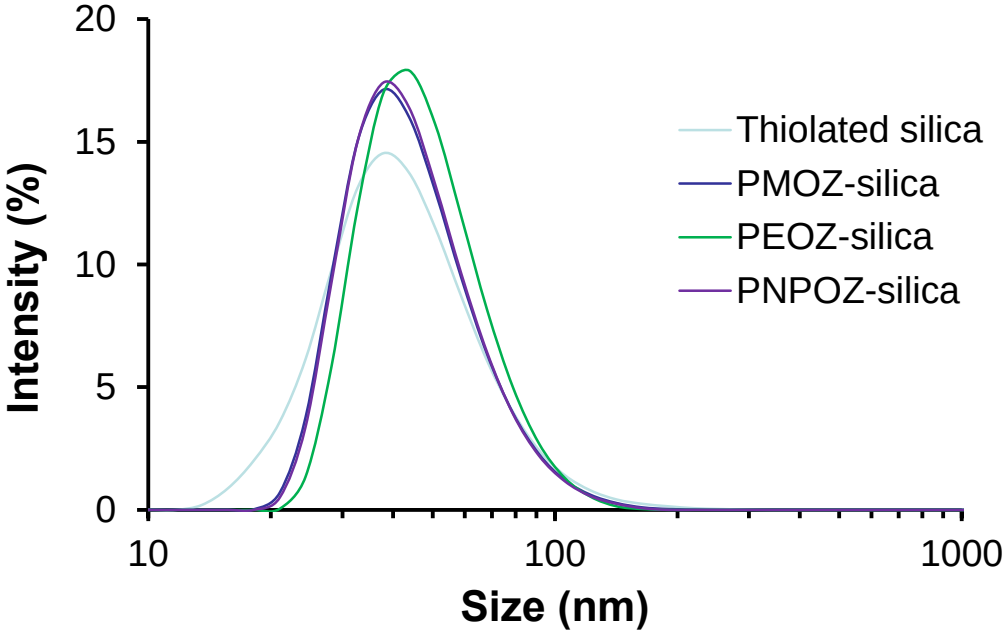
Ethyl-POZ
(PEOZ)

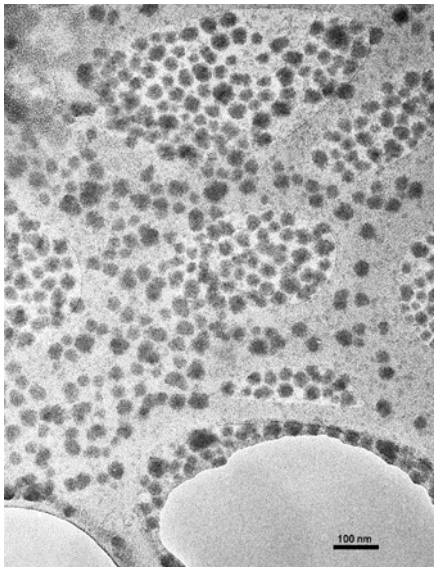


N-propyl-POZ
(PNPOZ)

These polymers were provided by Prof Richard Hoogenboom (University of Ghent)

Characterisation

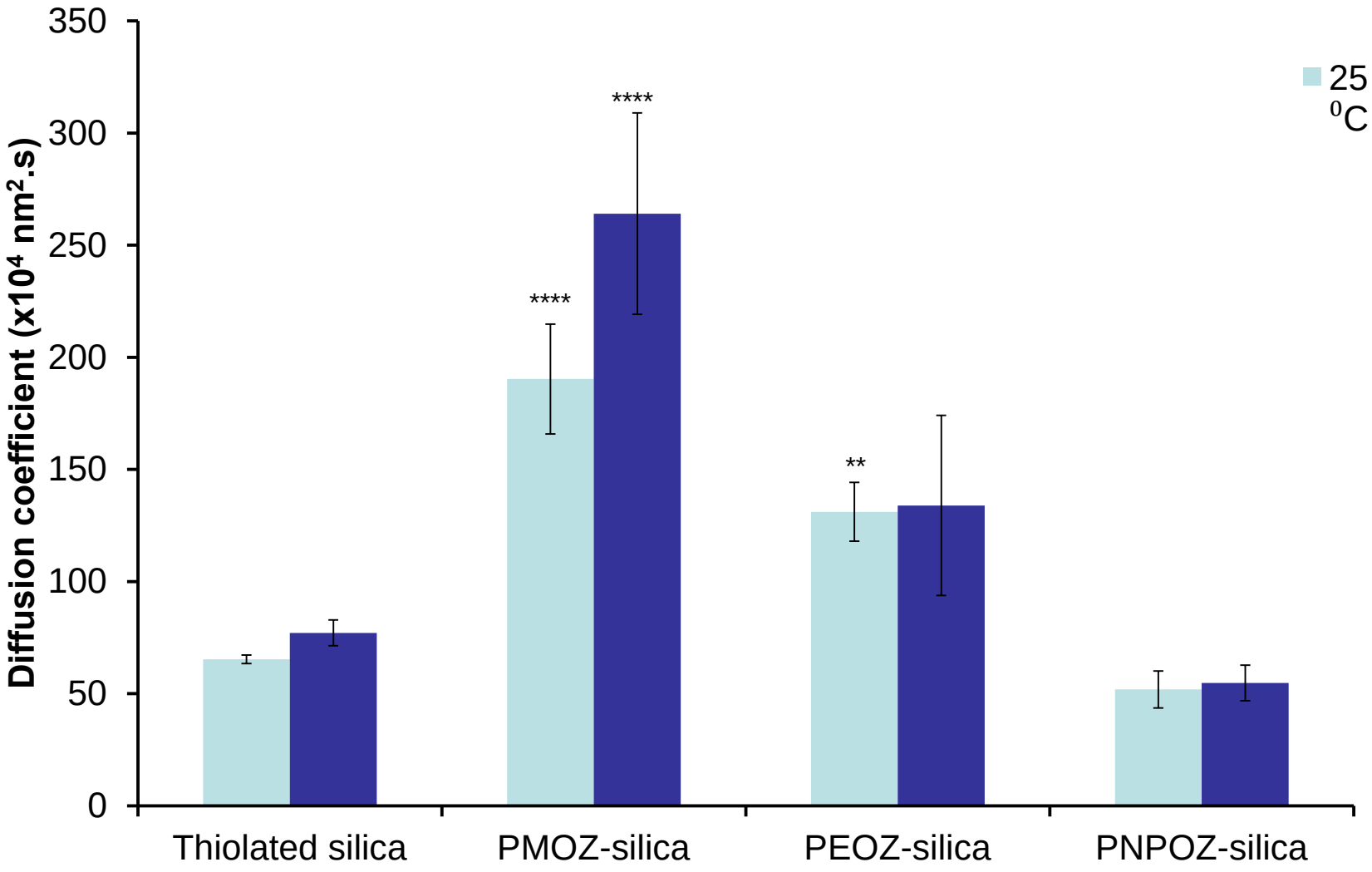




Nanoparticle	z-average (nm)	PDI	ξ-potential (mV)	Mode diameter (nm)
Thiolated silica	52±1	0.072	-46±2	54±1
PMOZ-silica	61±4	0.188	-23±1	61±4
PEOZ-silica	59±1	0.106	-20±2	59±1
PNPOZ-silica	61±1	0.194	-21±2	63±3

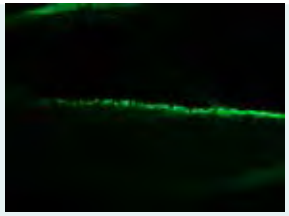
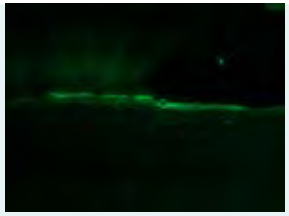
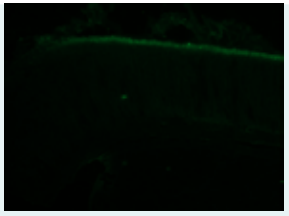
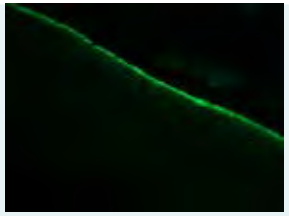
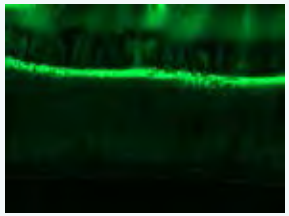
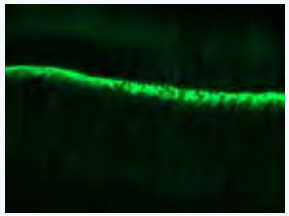
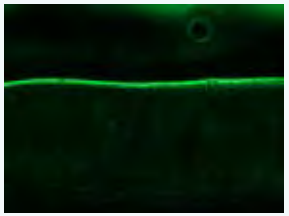
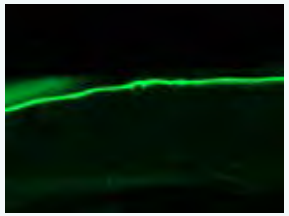
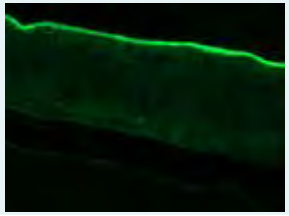
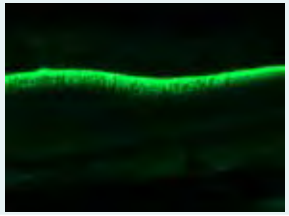
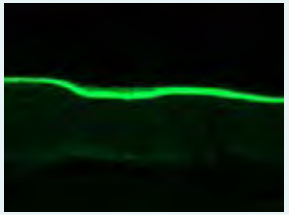
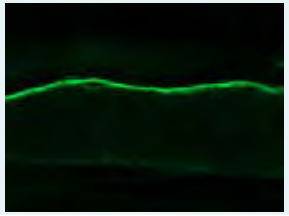
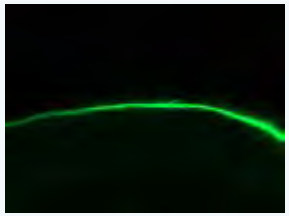
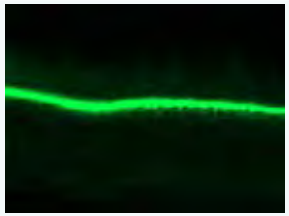
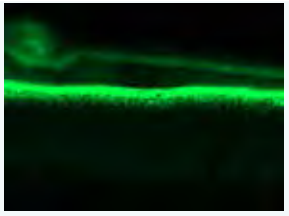
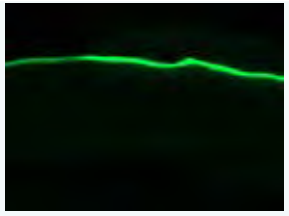
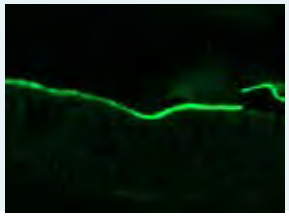
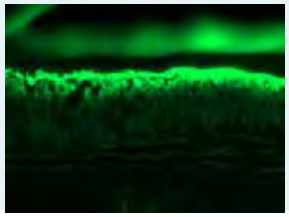
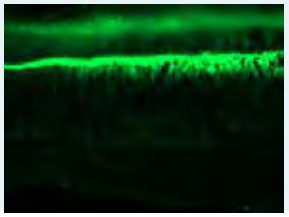
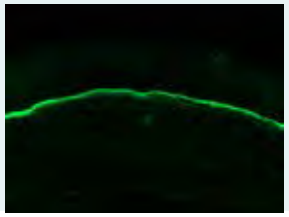
Mansfield et al, unpublished (2016)

Diffusion in mucus studied using NTA

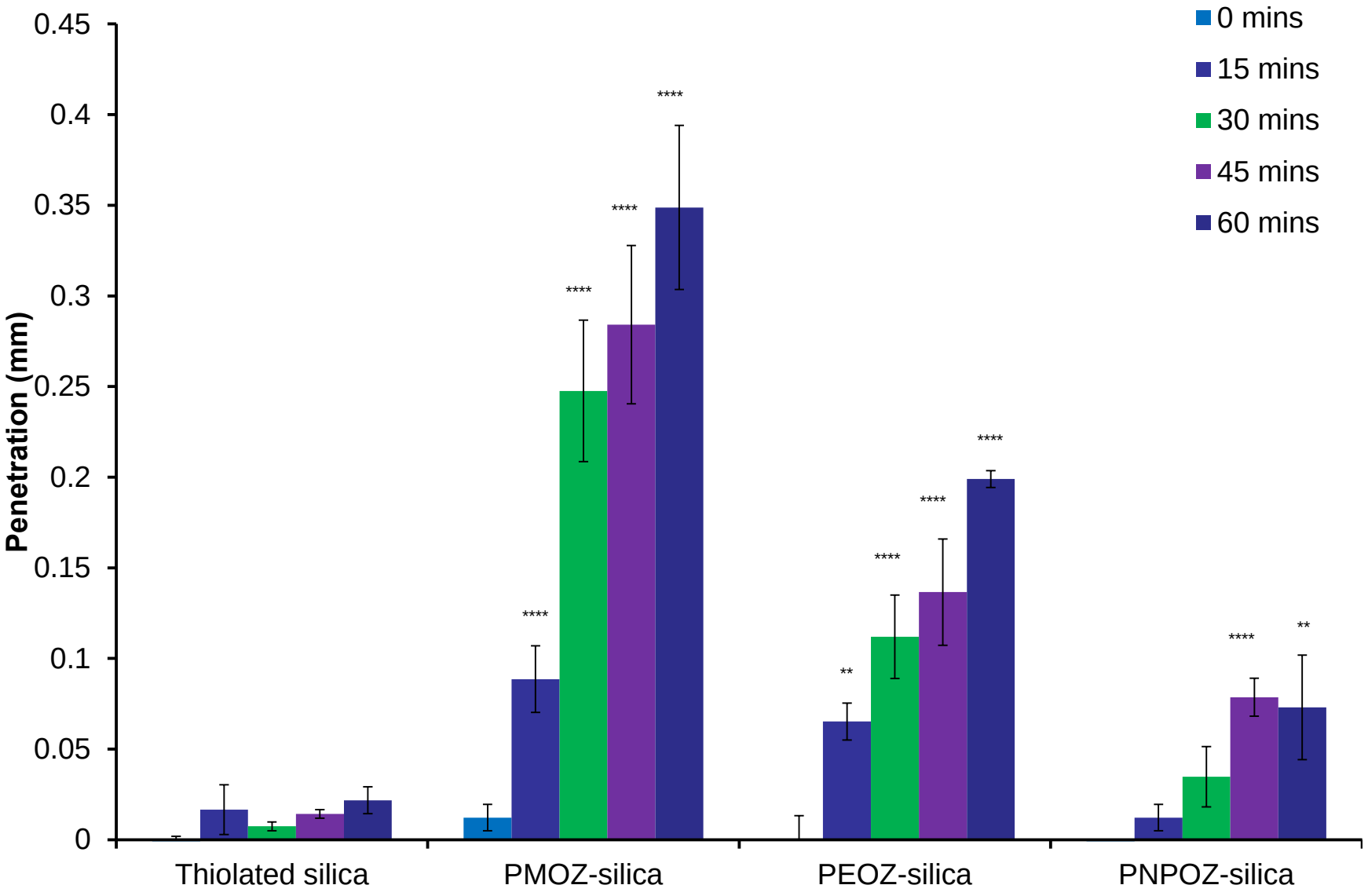


Mansfield et al, unpublished (2016)

Ex vivo mucosa penetration

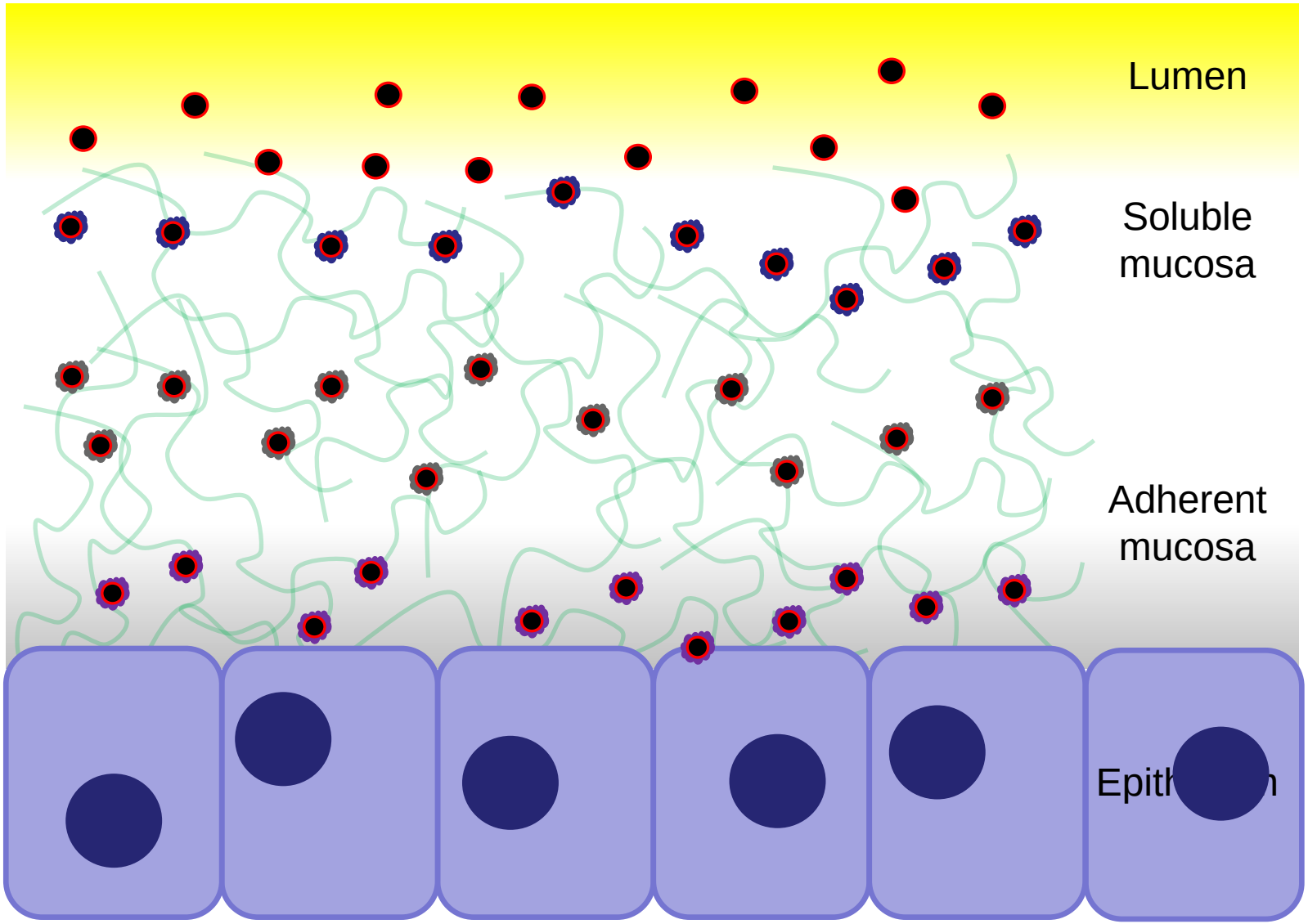
	Thiolated silica	PMOZ	PEOZ	PNPOZ
0 mins				
15 mins				
30 mins				
45 mins				
60 mins				

Ex vivo mucosal penetration



Mansfield et al, unpublished (2016)

Effect of particle surface chemistry on mucosal penetration



Conclusions

- NTA is a powerful technique for characterisation of nanoparticles in liquid media
- NTA can be used to study nanoparticle diffusion and interactions in liquid media
- Diffusion in synthetic polymer solutions and biological fluids/gel is highly dependent on particle dimensions and surface chemistry

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