A rigorous protocol for evaluating the effectiveness of gloves against nanoparticles in solution

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- **Majority of the studies use engineering nanoparticles (ENP) in aerosol**

  Graphite – 30/40 and 80 nm (Golanski et al. 2009)

  TiO_2 – 10 nm (Golanski et al. 2009)

  Silver – 10 to 150 nm (Park et al. 2011)

→ **Few studies with ENP in solution**

- **Simulate the occupational use of the gloves**

  Repeated mechanical deformations (Dolez et al. 2011)

  Microclimate in the glove (sweat) (Lambers et al. 2006, Vinches et al. 2016)

→ **Development of a test setup**

- **How to measure the real quantity of ENP which passes through the gloves ?**

  Use the right devices (Vinches et al. submitted)

  Evaluate the losses of ENP (Vinches et al. submitted)

Summarize the different necessary steps
to evaluate the effectiveness
of disposable protective gloves against ENP in solution

Nitrile rubber gloves

t = 73.2 ± 3.0 µm

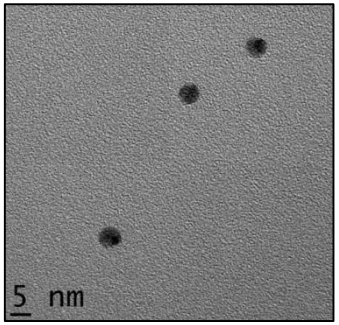
NBR-1a	NBR-1b	NBR-2	NBR-3
Batch 1 – Box a February 2015	Batch 1 – Box b February 2015	Batch 2 September 2015	Batch 3 March 2014

Commercial gold suspension

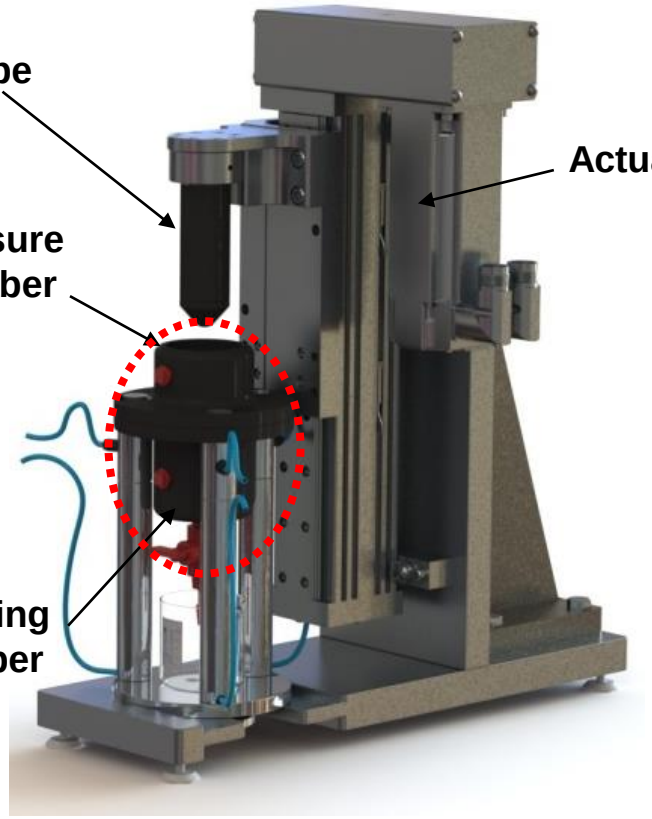
5 nm, PVP, 0.05 mg/mL in MilliQ water

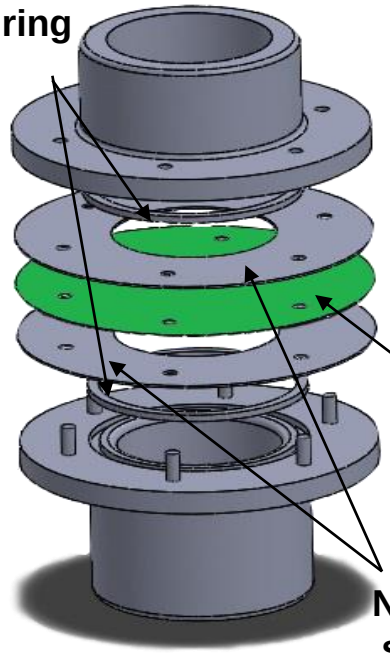
TEM diameter = 5.0 ± 0.6 nm

Hydrodynamic diameter (DLS) = 9.2 ± 0.6 nm



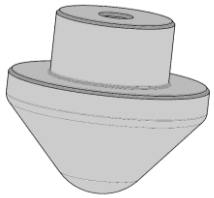
Setup to simulate the hand flexing and the microclimate into the glove (sweat)

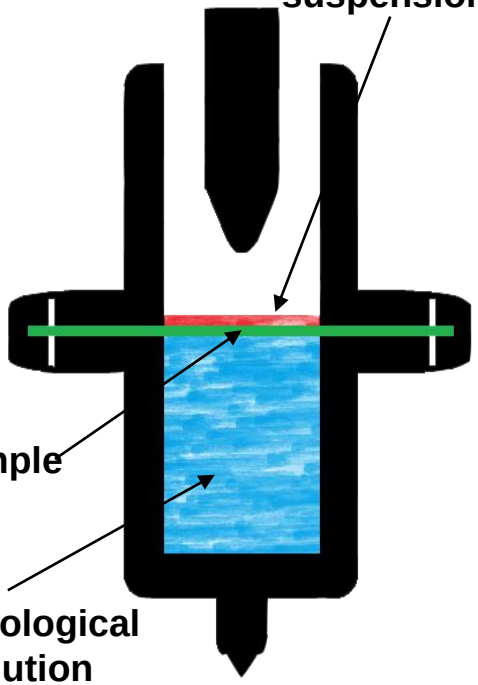




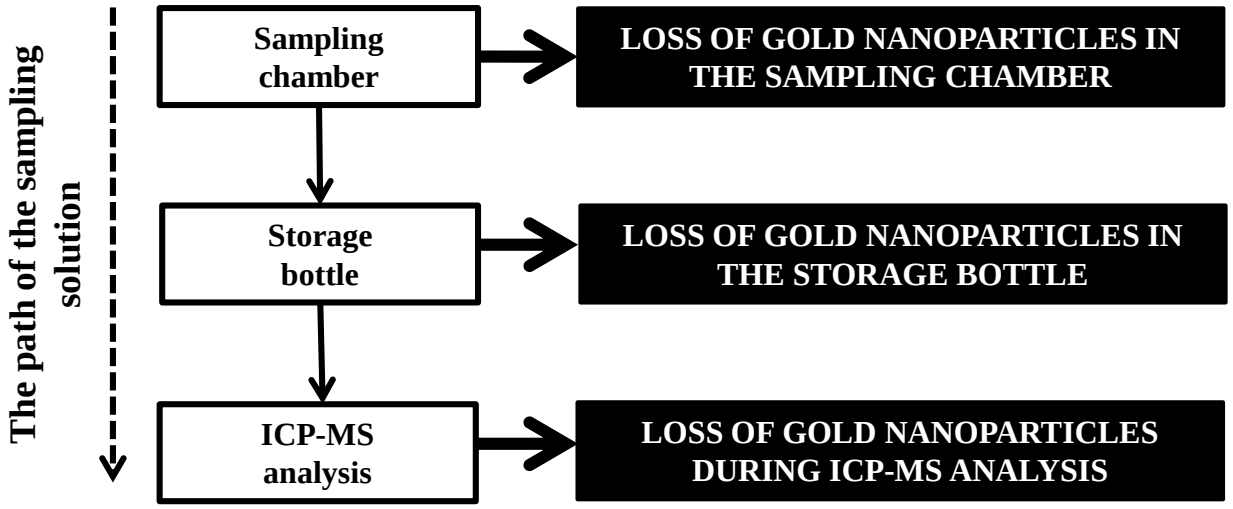
30 mm-MD

each 10 s during 3 hours





Origins in the loss of nanoparticles



Evaluation of the effectiveness of gloves in *FOUR* steps

- 1 -
Selecting the storage bottles to minimize losses

- 2 -
Evaluating the losses throughout the test

- 3 -
Performing the mechanical deformations test

- 4 -
Analysing sampling solution by ICPMS

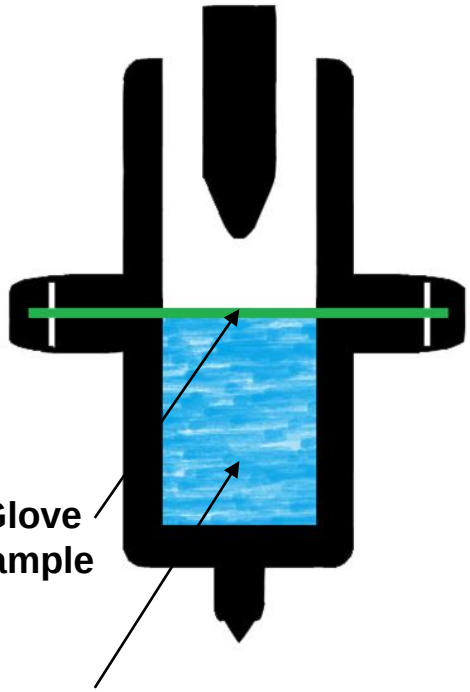
- Preparation of a gold suspension at a nominal concentration of 10 µg/L (concentration expected based on previous work) in physiological solution at pH = 6.
- Storage in bottles of six different chemical compositions.
- ICPMS analysis after 0, 24, 48 and 72 hours.

Restitution coefficient (%)

	After 24 hours	After 72 hours
Glass	100	100
Polycarbonate	75	65
Polypropylene	70	50
Teflon	65	50
Low Density Polyethylene	60	40
High Density Polyethylene	50	30

Use of glass bottles as storage bottles for gold nanoparticles in solution

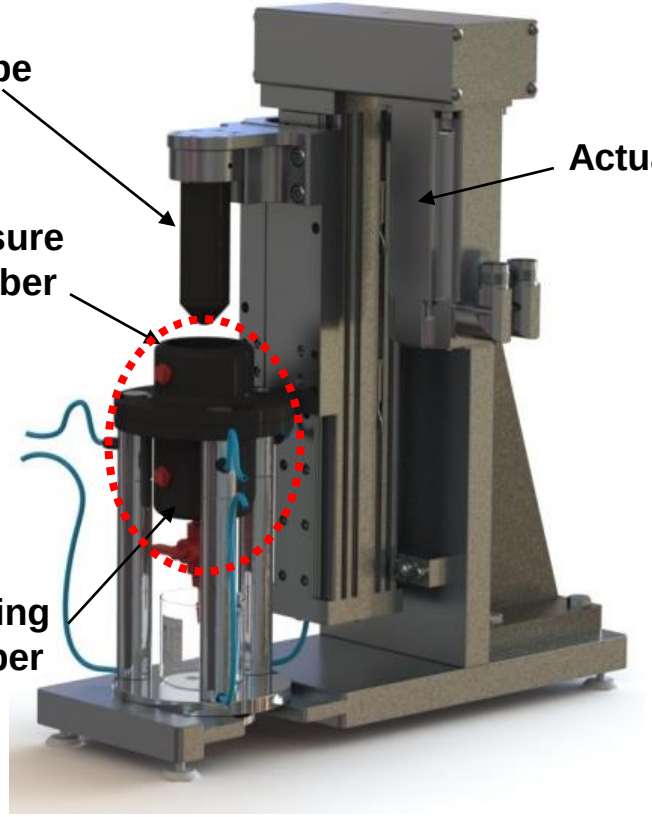
- Preparation of two gold suspensions at a nominal concentration of 10 µg/L and 100 µg/L in physiological solution at pH = 6
- The physiological solution replaced by the 10 or 100 µg/L gold suspensions
- No commercial nanoparticle suspension in the exposure chamber

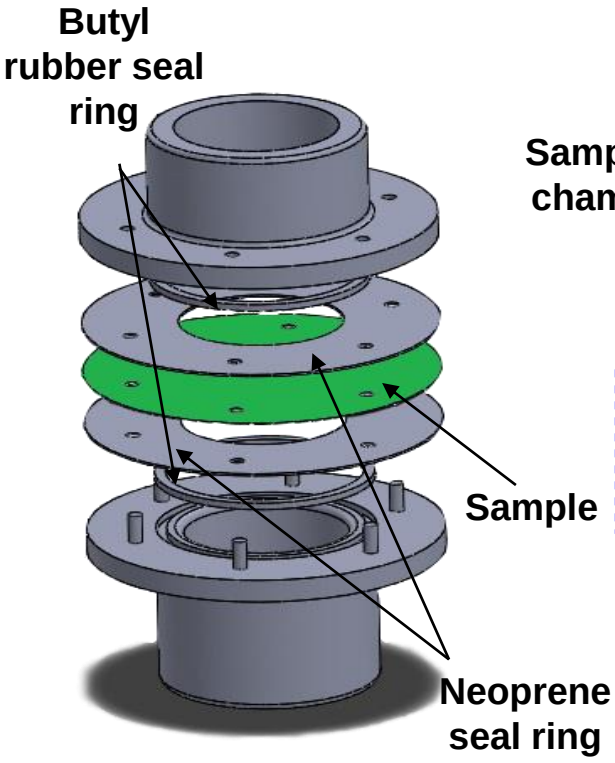


$$\text{Loss coefficient(LC)} = \frac{\text{Gold concentration after the test}}{\text{Initial gold concentration}}$$

For low gold concentrations (10 µg/L)
LC = 51.0 ± 0.1 %

For high gold concentrations (100 µg/L)
LC = 41.0 ± 0.1 %





30 mm-MD

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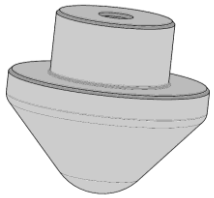

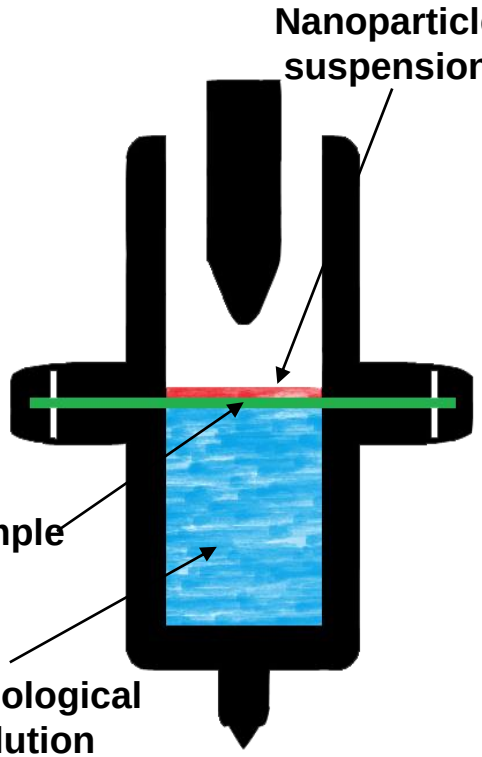

Step 4 : Gold nanoparticle penetration: ICP-MS results

	M±SD (µg/L) (n=10)	Maximal Concentration (µg/L)	Minimal Concentration (µg/L)
NBR-1a (Feb. 2015)	0.446 ± 0.162	0.782	0.319
NBR-1b (Feb. 2015)	0.530 ± 0.524	1.802	0.172
NBR-2 (Sept. 2015)	1.662 ± 2.994	10.028	0.162
NBR-3 (March 2014)	0.273 ± 0.132	0.477	< LOD

1. Passage of gold nanoparticles through this model of nitrile glove indicating its low effectiveness
2. A 13 fold difference in the maximum for different batches
3. !! The oldest batch of gloves offers the best protection against gold nanoparticles and the newest batch offer the worst protection !!

RIGOROUS METHODOLOGY TO EVALUATE THE EFFECTIVENESS OF PROTECTIVE DISPOSABLE GLOVES AGAINST NANOPARTICLES IN SOLUTION

IDENTIFICATION OF FOUR IMPORTANT STEPS

1- Determine the most suitable storage bottles for the sampling solution

2- Evaluate the loss coefficient of the sampling protocol

3- Perform the permeation test

4- Measure the permeation of ENPs through disposable protective gloves

Clean the different parts of the test setup to minimise contamination.

Limitation of this methodology :
The four steps must be performed for each type of nanoparticles in solution

Effectiveness results :

- **Significant concentrations of gold nanoparticles observed in the sampling solution**
- **Depending on the batch and on the box (variability in the manufacturing process)**
- **Permeation of ENP due to a loss of integrity of the elastomer (MD and swelling)**

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Thank you for your attention