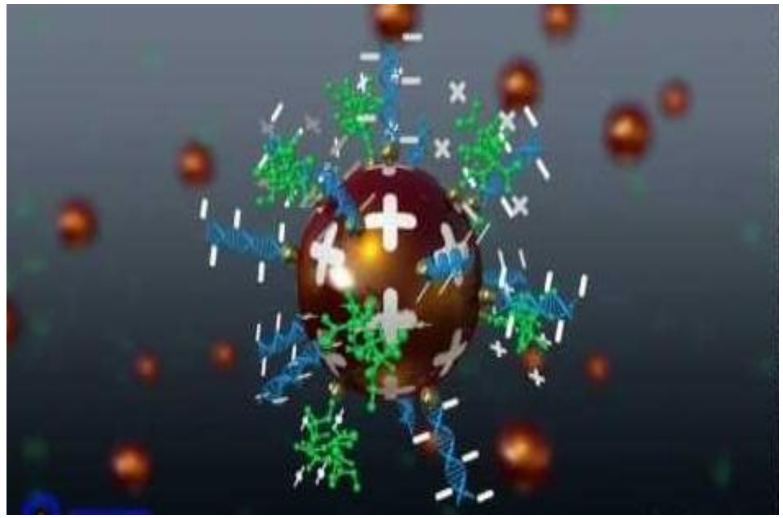
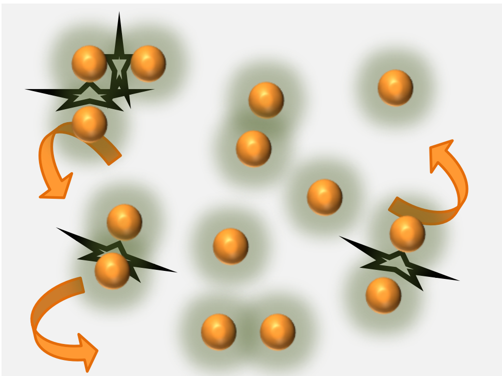


An introduction to electrophoresis principle for particle charge measurements

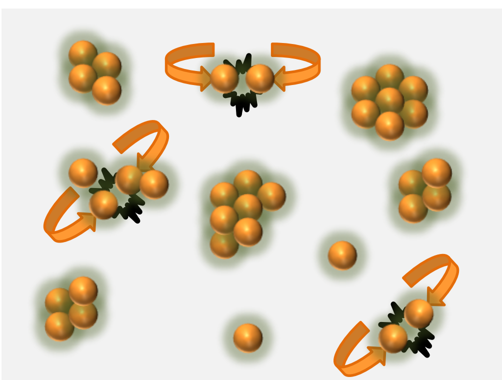
CORDOUAN Technologies

2013/10/17

Why measuring Zeta potential?

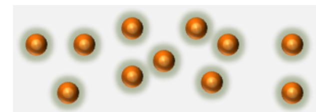


Charged particles repel each other

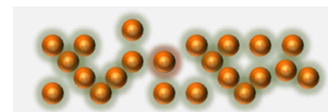


Uncharged particles are free to collide and aggregate

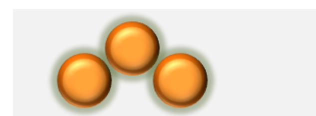
Colloidal solution stability ?



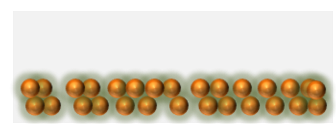
Stable systems



Flocculations



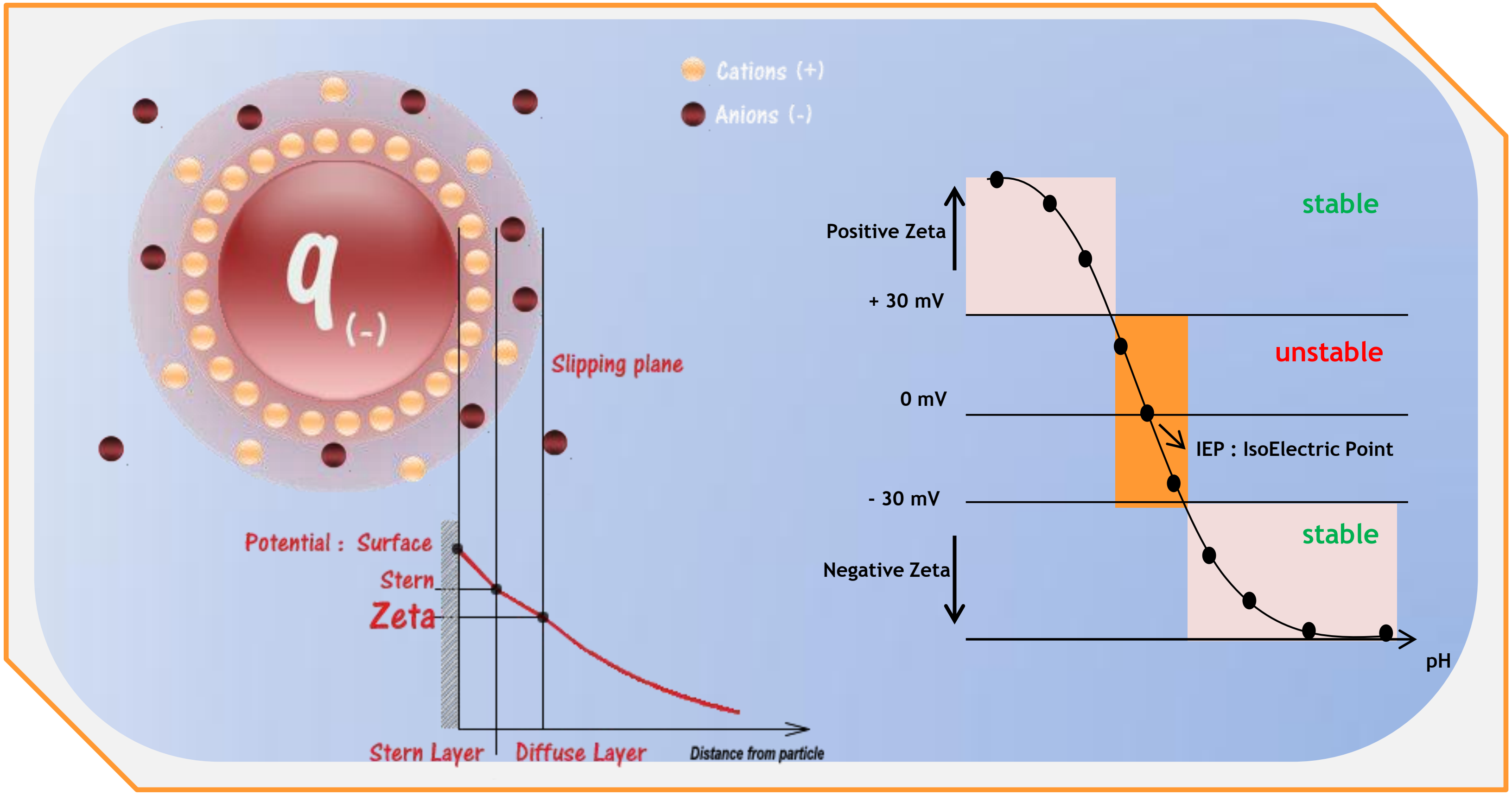
Coagulation



Sedimentation

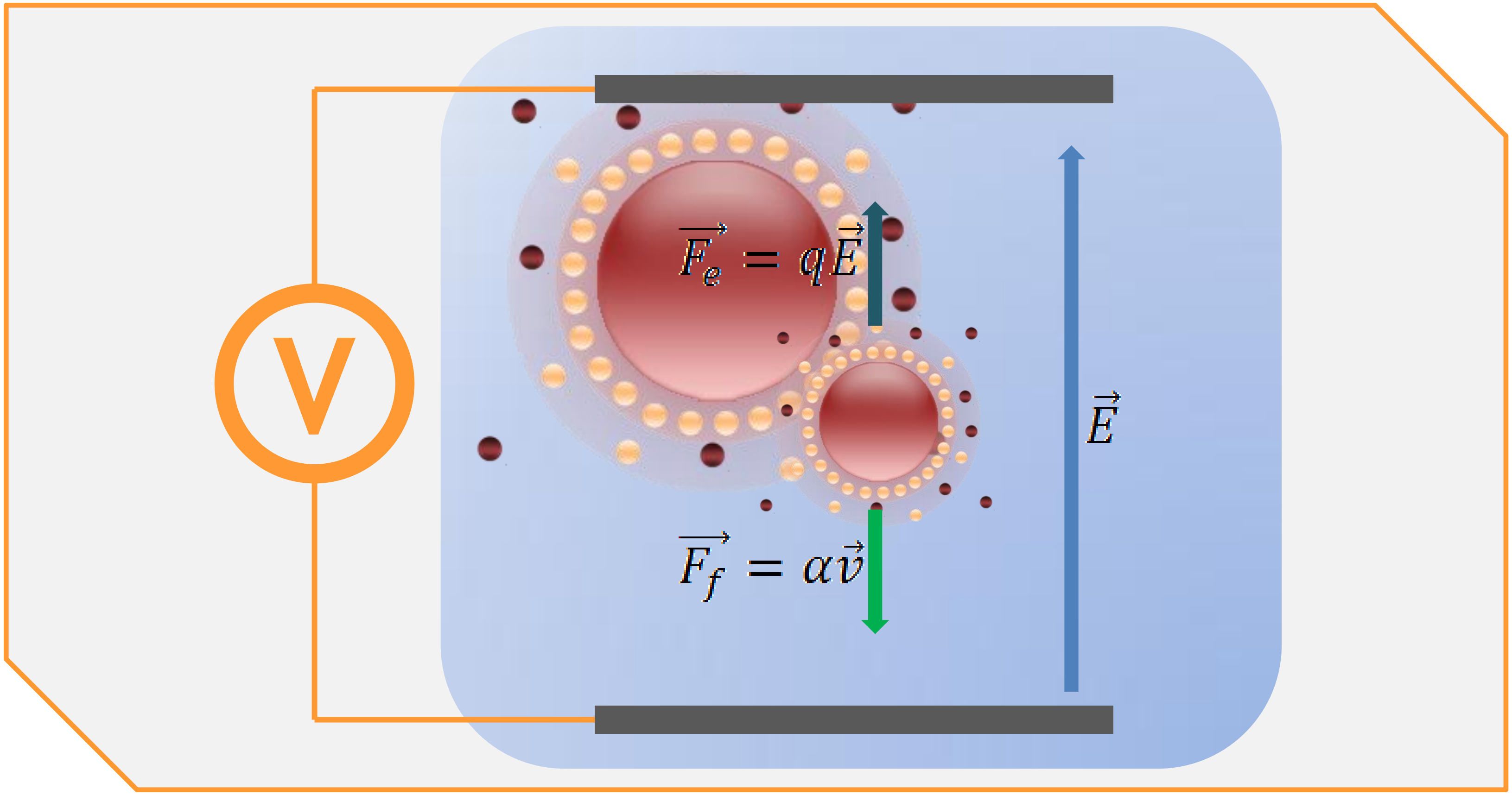
- Electrostatic or charge stabilization : This effect uses more natural interactions between particles through the distribution of charged species (ions) in the solution.

Zeta Potential definition



- If surface has - charge, then Cations are attracted to surface
- Anions attracted to Cations, builds electric double layer
- Slipping plane: distance from particle surface where ions move with particle
- Zeta Potential = potential (mV) at slipping plane

Electrophoresis Effect



Applying an Electric filed: Only strongly attached ions move with the particle.

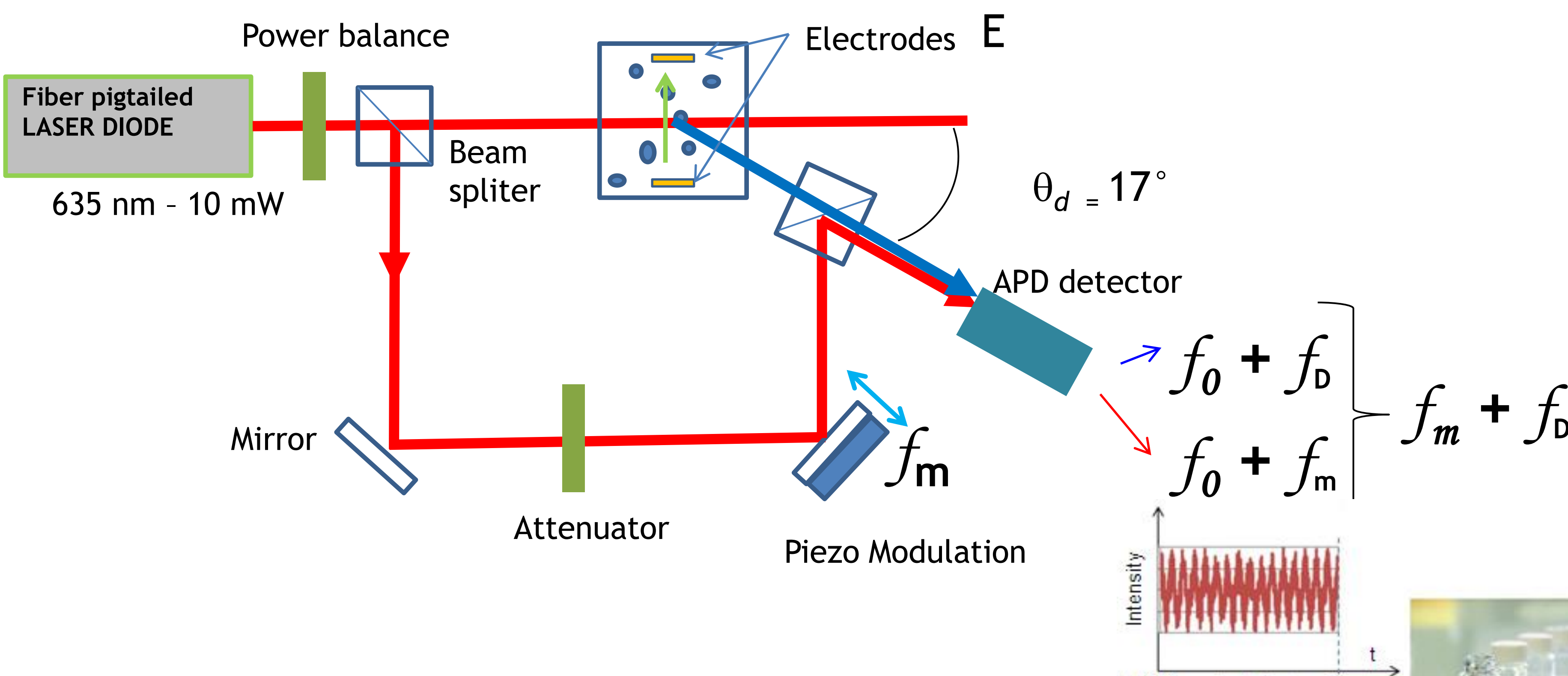
Particle velocity relies directly to its electrophoretic mobility under a known E-field

Laser Doppler Electrophoresis (LDE) principle

The Idea:

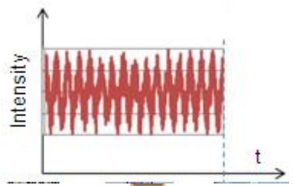
- **measure the speed of the charged nano particles by applying a known electric fields**
- **use a laser and the Doppler shit to measure the averaged speed of the particles**

Heterodyne optical Interferometer



Measurement Sequence

Heterodyning Signal



FFT

Doppler shift

$f_{\mathbf{D}}$

Measured

Electrophoretic Mobility

μ_e

By ***LDE***
(Laser Doppler Electrophoresis)

Double Layer model

Huckel ?
Smoluchowski ?

$f(\kappa.a)$
Henry function

Computed

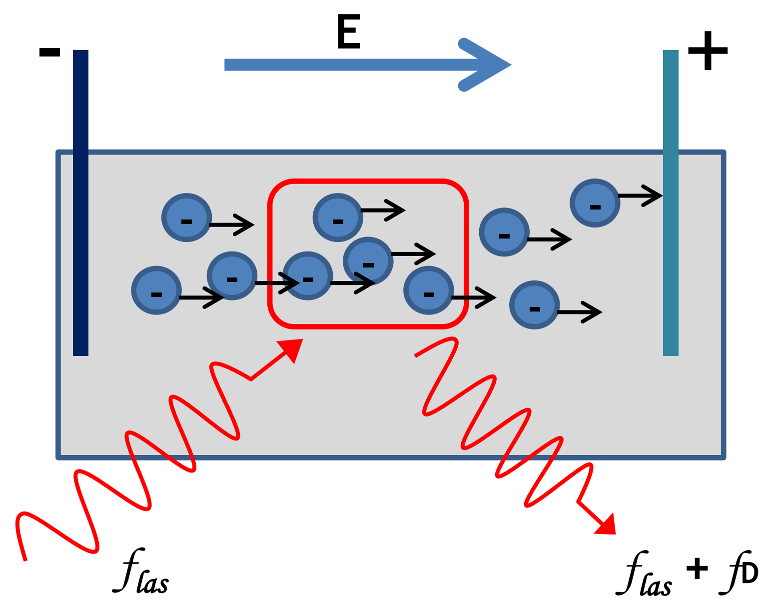
Zeta Potential

ζ

Measurement of mobility

Electrophoretic mobility

$$\mu_e = \frac{\lambda}{E \sin \theta_d} f_D$$



Where :
μe: electrophoretic mobility (μmcm/Vs)
E : applied electric field
f_{las} : laser frequency
f_D : Doppler frequency

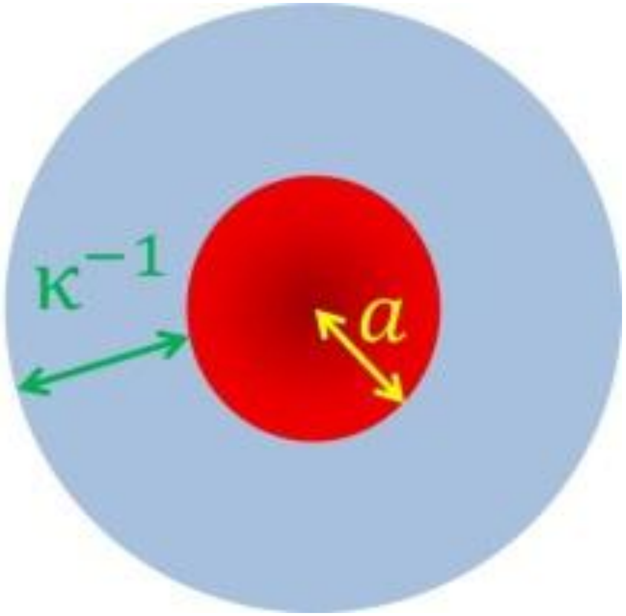
Particle motion causes Doppler shift
Frequency -> mobility

Zeta Potential : Calculation of ZETA

Zeta potential

$$\zeta = \mu_e \frac{\eta}{\varepsilon} f(\kappa.a)$$

Where :
ζ: Zeta Potential (mV)
μ_e: electrophoretic mobility
ε: medium permittivity
η: medium viscosity
a: particle radius
κ: invert of double layer thickness
κ^{-1} : Debye length
$f(\kappa.a)$: Henry's function

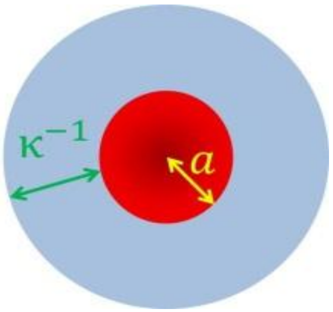


Zeta is dependent of the $\kappa.a$ factor value

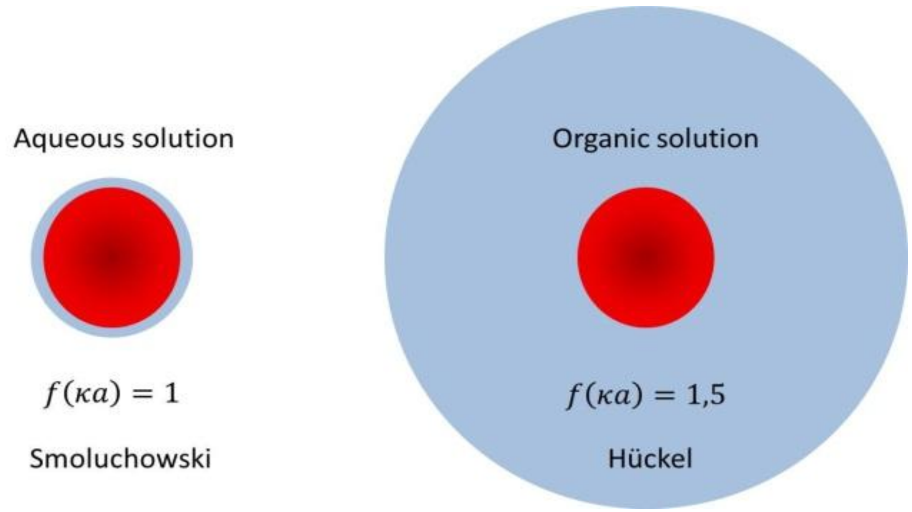
κ is dependent of the solvent

Zeta Potential : Fundamental equation

General cases



$1 \leq f(\kappa.a) \leq 1.5$



Calculated   Measured

$$\zeta = \mu_e \frac{\eta}{\varepsilon} f(\kappa.a)$$

Needs to know the value !

<u>99% cases !!!</u>

Zeta potential calculation is based on the knowledge of the double layer, define by Henry function f(κ.a).

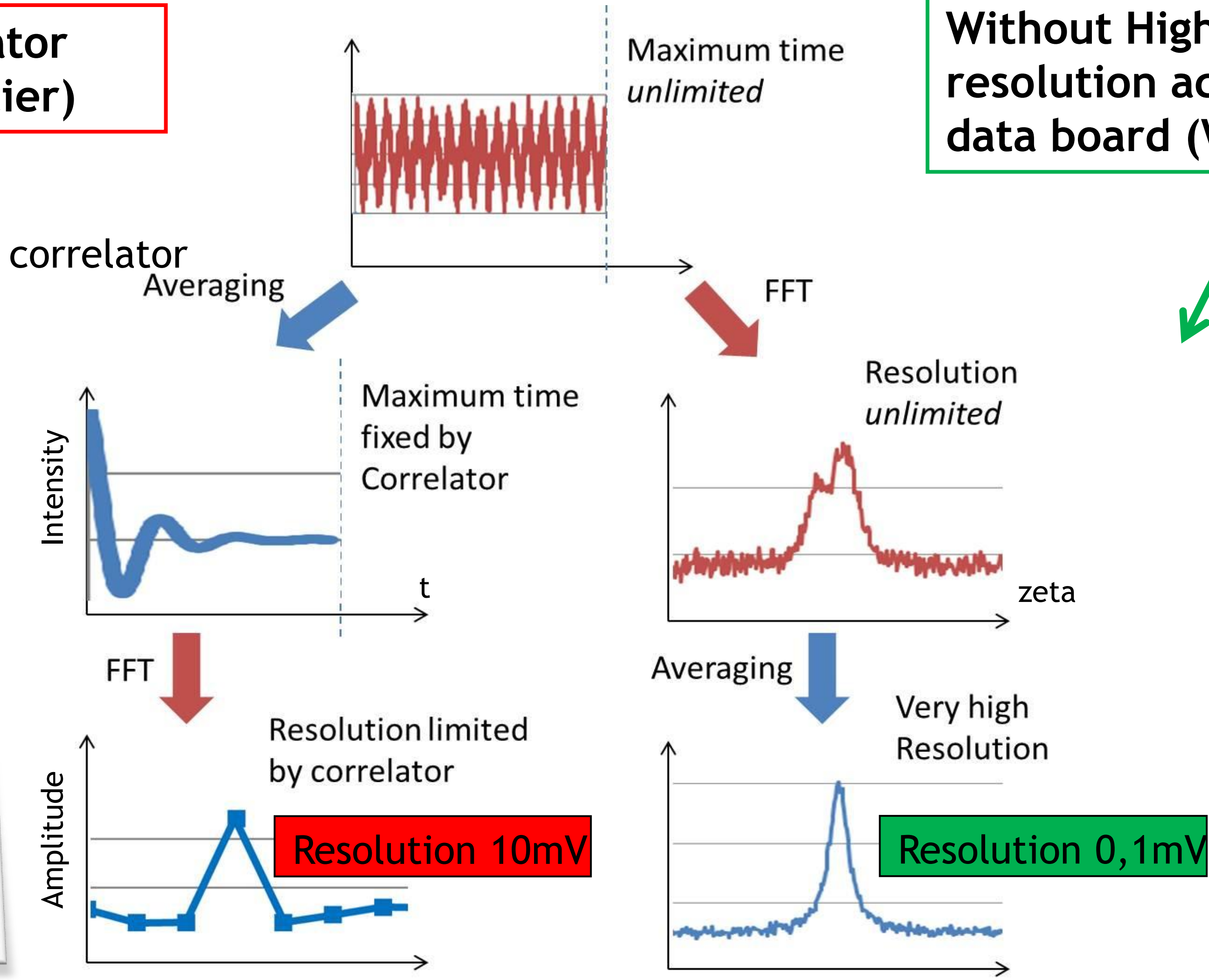
WALLIS ζ: High-Resolution Zeta Potential Analysis

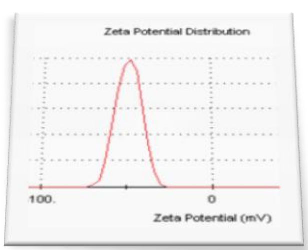
- Charge/zeta potential measurement of nano-particles in suspension
- Complementary tool to VASCO for colloid characterization
- High resolution analysis from -200mV to + 200mV

Direct acquisition : No correlator for higher resolution

With correlator (other supplier)

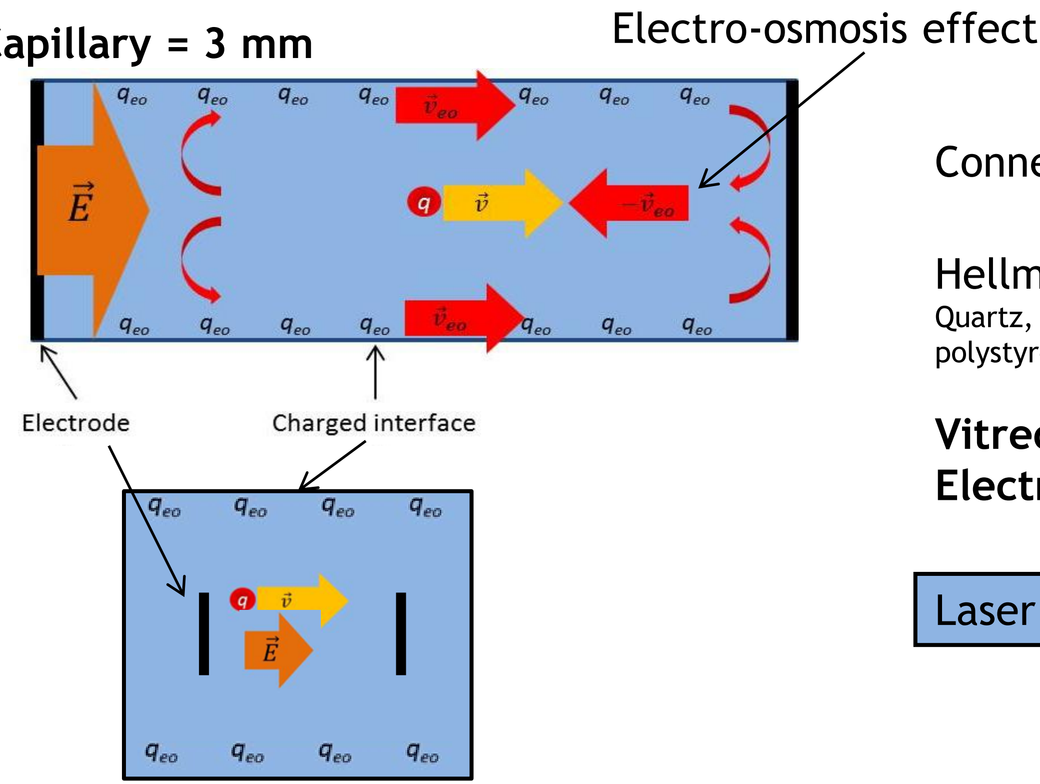
Without High resolution acquisition data board (Wallis)



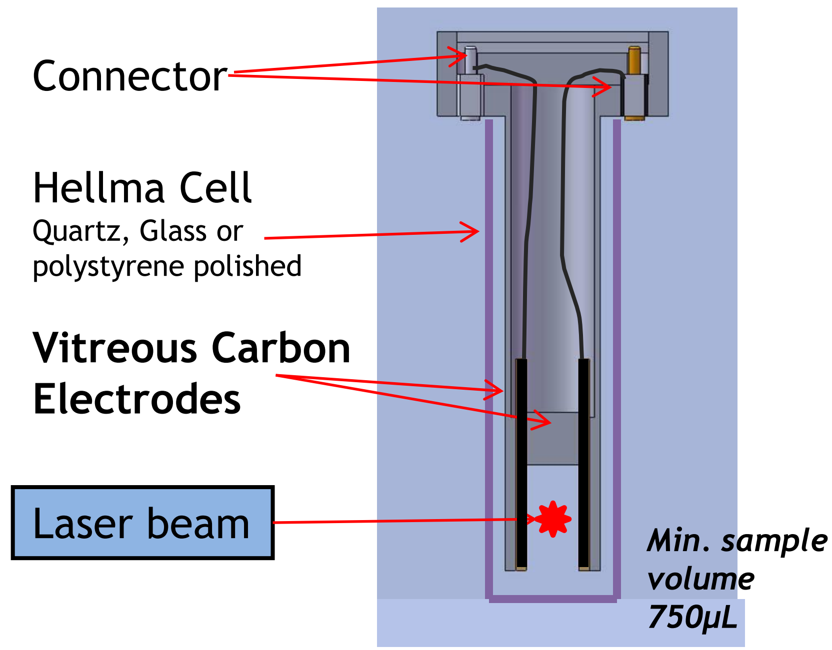


Electrode Assembly

Capillary = 3 mm



Dip cell = 10 mm



The Dip cell small electrodes configuration is based on established principles.
No electro-osmosis in WALLIS cell ▸ The need to focus at any "stationary plane" is eliminated.

Electrode Assembly

Concept oriented for handling easiness

- Easy filling from above !
- No risk of bubbles ! (vs capillary cell)

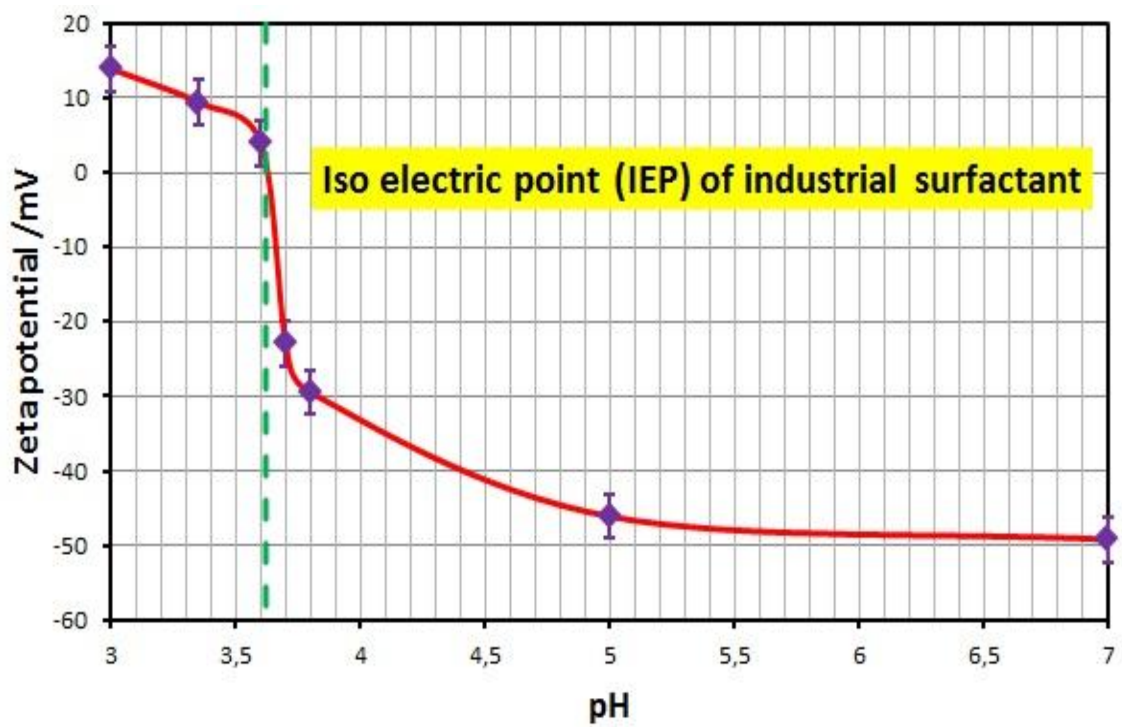
- Electrodes are independent (moderate cost)
- Vitreous carbon electrodes (lifetime> 1 year - extreme resistance to chemical attack - low electrical resistance)
- Conventional cleaning of electrodes (ultra sound or bath tub)

- Life of a quartz cell (> 5 years)
- Excellent optical quality (quartz and / or polystyrene polished !)
- Compatible with organic solvent
- Compatible with Hellma cell …

Example : sample of industrial surfactant

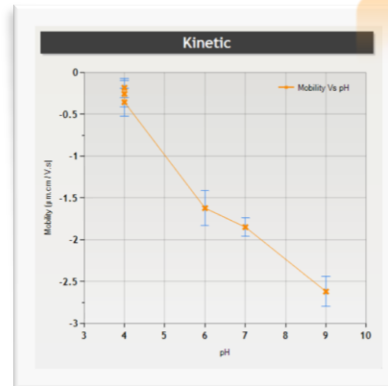
High resolution of Wallis allow high quality measurement for applications:

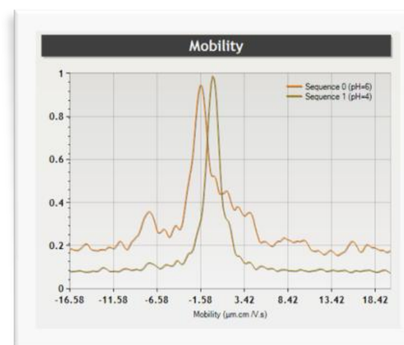
- Precise measurement of IEP
- Functionalization of colloid
- Repeatability of particles synthesis
- Sharp variation in particles stability



ZetaQ

- Unique and proprietary software
- User friendly and touch-screen oriented
- Database structure





Thank you of your attention!

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