Using Zeta Potential to Optimize Wastewater Treatment

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Wastewater

- Wastewater contains chemical and particulate contaminants that need to be removed for safety, environmental, and aesthetic reasons.

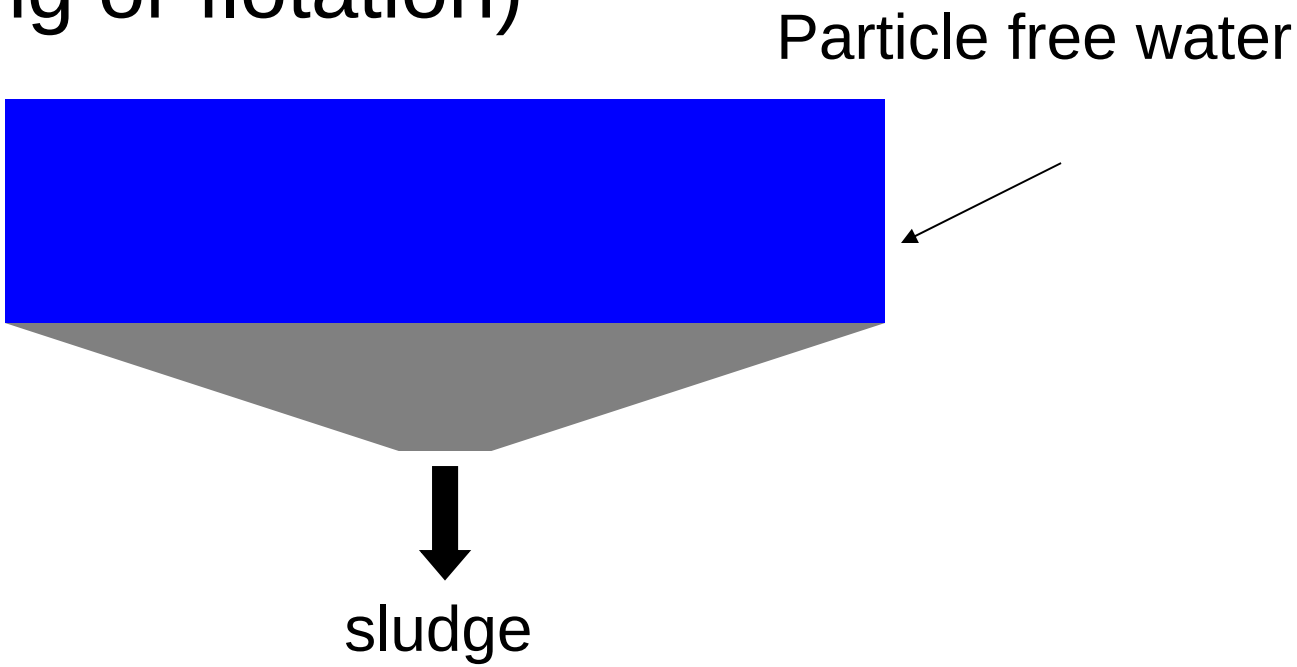
- Today we primarily talk about particulate waste.

How do we look at particle contamination?

- Suspended particles will appear as haze and can be measured with
  - Turbidity meter – scattered intensity at right angle
  - Total suspended solids (filter and weigh)
- See US EPA: Analytical Method for Turbidity Measurement, Method 180.1
- See the HORIBA U-53 for measuring turbidity

Getting Rid of Particles

- Put them in a giant tank and wait (settling or flotation)



- Filter particles out with filter media

Stokes Law

- Particle settling velocity increases by square of particle size. If you double particle size, particles settle four times faster.

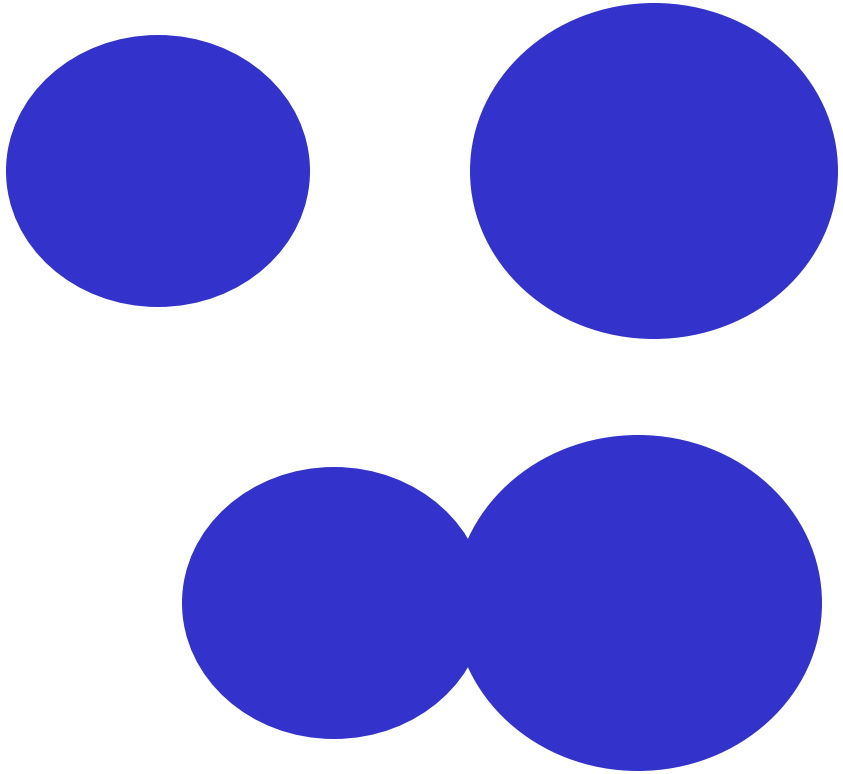
$$v = \frac{2(\rho_p - \rho_f)gr^2}{9\eta}$$

v = velocity (down is positive)
ρ_p = density of particle
ρ_f = density of fluid
g = acceleration due to gravity
r = particle radius
η = fluid viscosity

- Larger Particles → Less expensive process

Fine Suspended Particles

Fine particles will tend to flocculate to reduce surface energy.



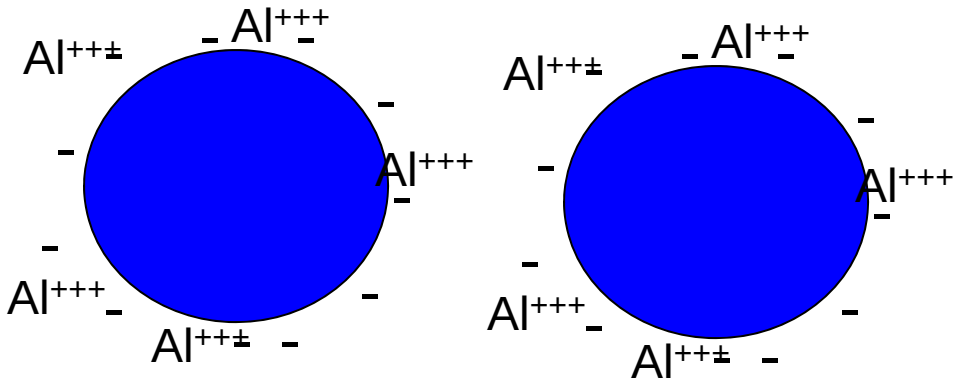
Less surface, lower free energy.

Why don’t particles flocculate?

Most particles in aqueous suspension have a surface charge and therefore repel each other; they never touch.

How do we suppress charge effects?

- If we can “turn off” the particle charge, then the particles will flocculate and more rapidly settle (or be more easily filtered).
- We can do this with coagulants and flocculants.
  - Multivalent ions: Ca++, Al+++
  - Polyelectrolytes: acrylamide/acrylic acid copolymers



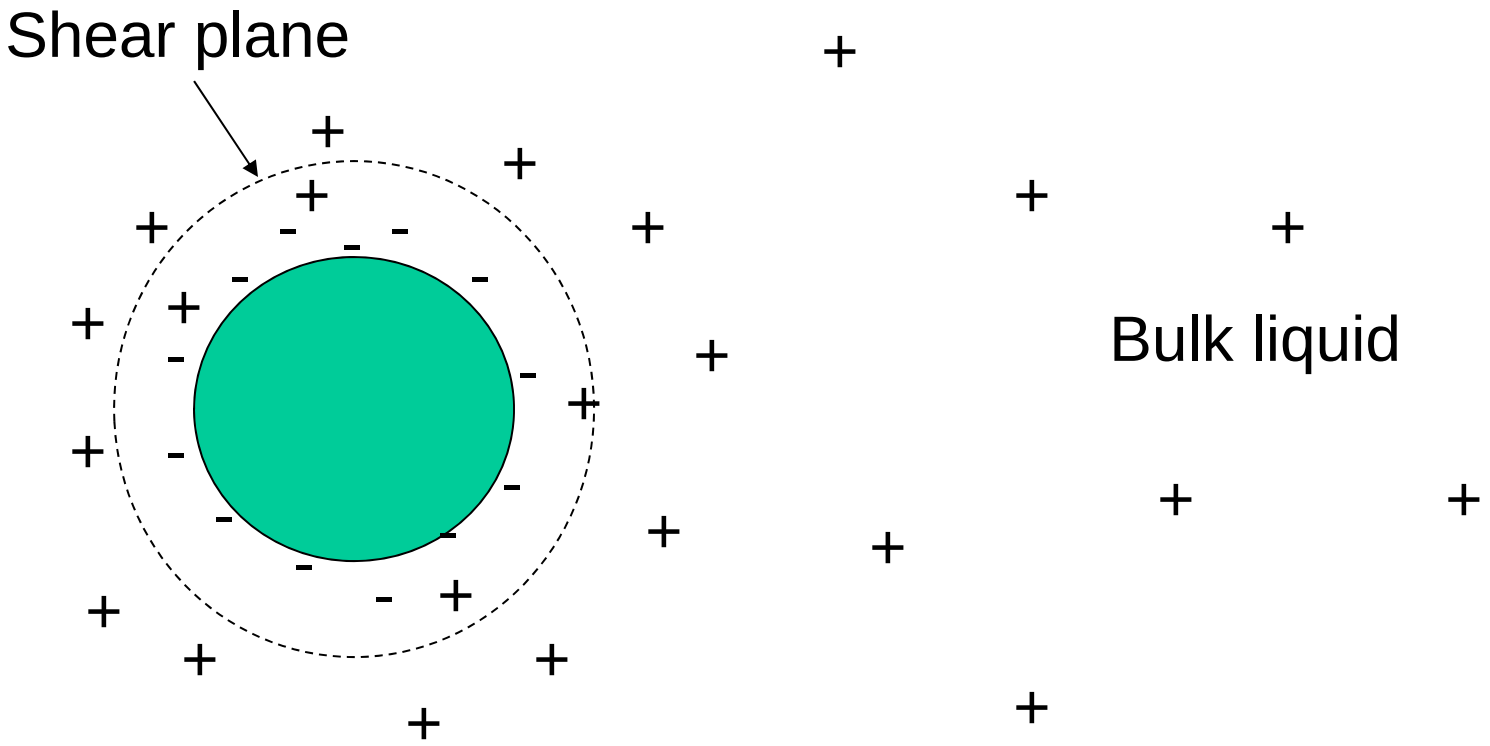
What is the Isoelectric Point?

- The Isoelectric Point is the point at which the zeta potential (surface charge) is zero.

- Achieved by the addition of
  - potential forming ions
  - Specific adsorption of charge modifying agents –the coagulents and flocculants mentioned earlier.

What is Zeta Potential?

- Zeta potential is the charge on a particle at the shear plane.



How to Measure Zeta Potential:

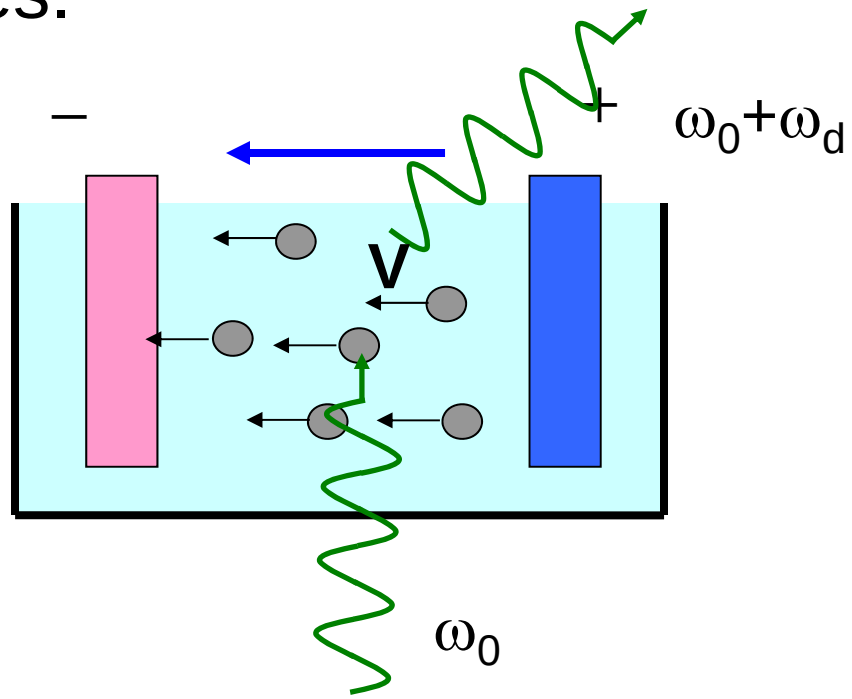
- Acoustic techniques (use sound to probe particle response)
- It is much more popular to use light scattering to probe motion of particles due to an applied electric field. This technique is known as electrophoretic light scattering.
- Used for determining electrophoretic mobility, zeta potential.

How to Measure? With the SZ-100

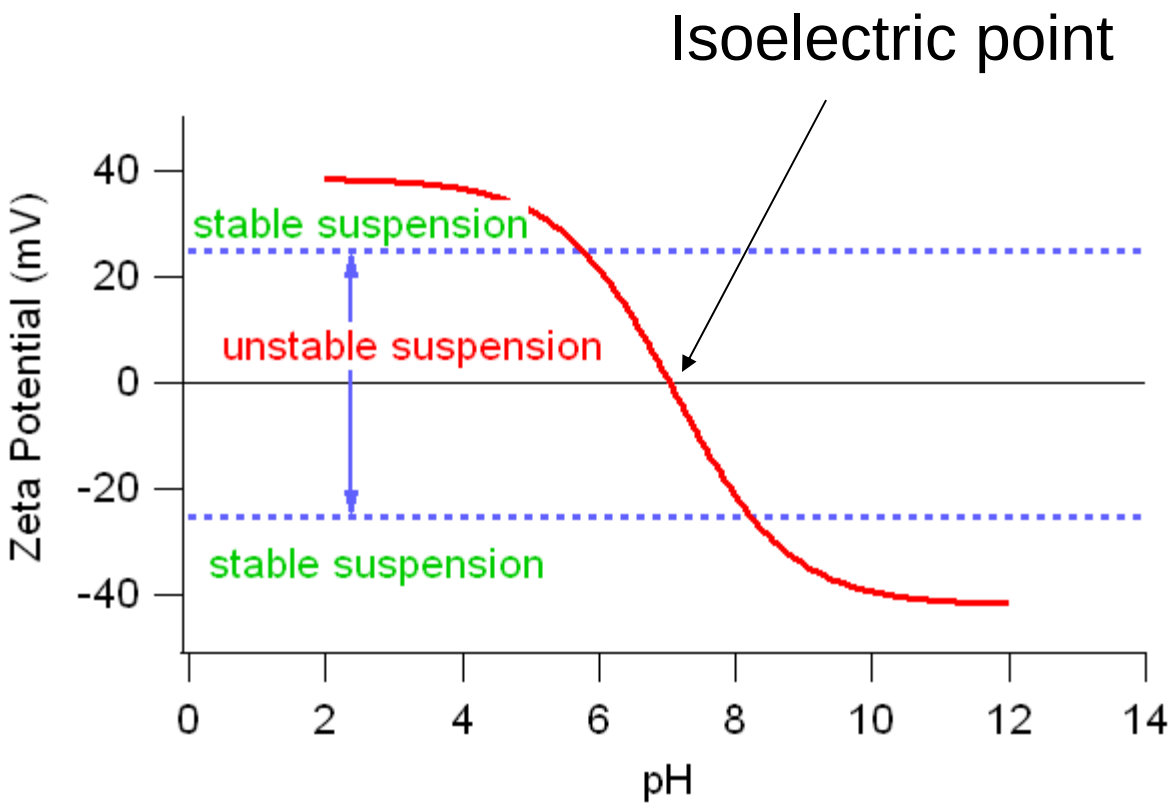
- Single compact unit that performs size, zeta potential, and molecular weight measurements: the SZ-100

How to determine zeta potential

- Apply an electric field and probe response of particles to applied field.
- You need to see Doppler shift in scattered light due to particle motion with respect to fixed electrodes.



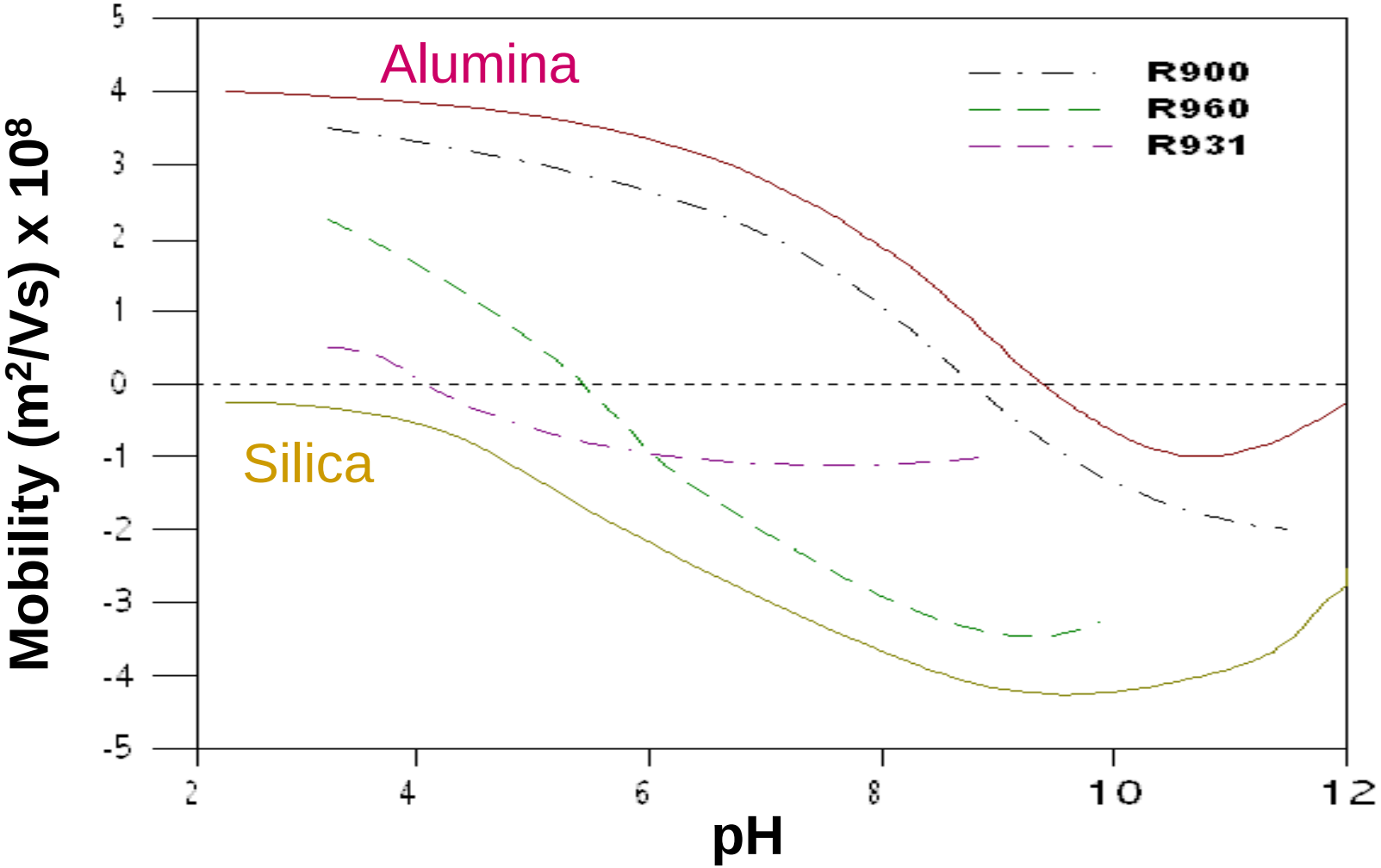
Isoelectric point



X-axis can also be Ca++ or other ion concentration.

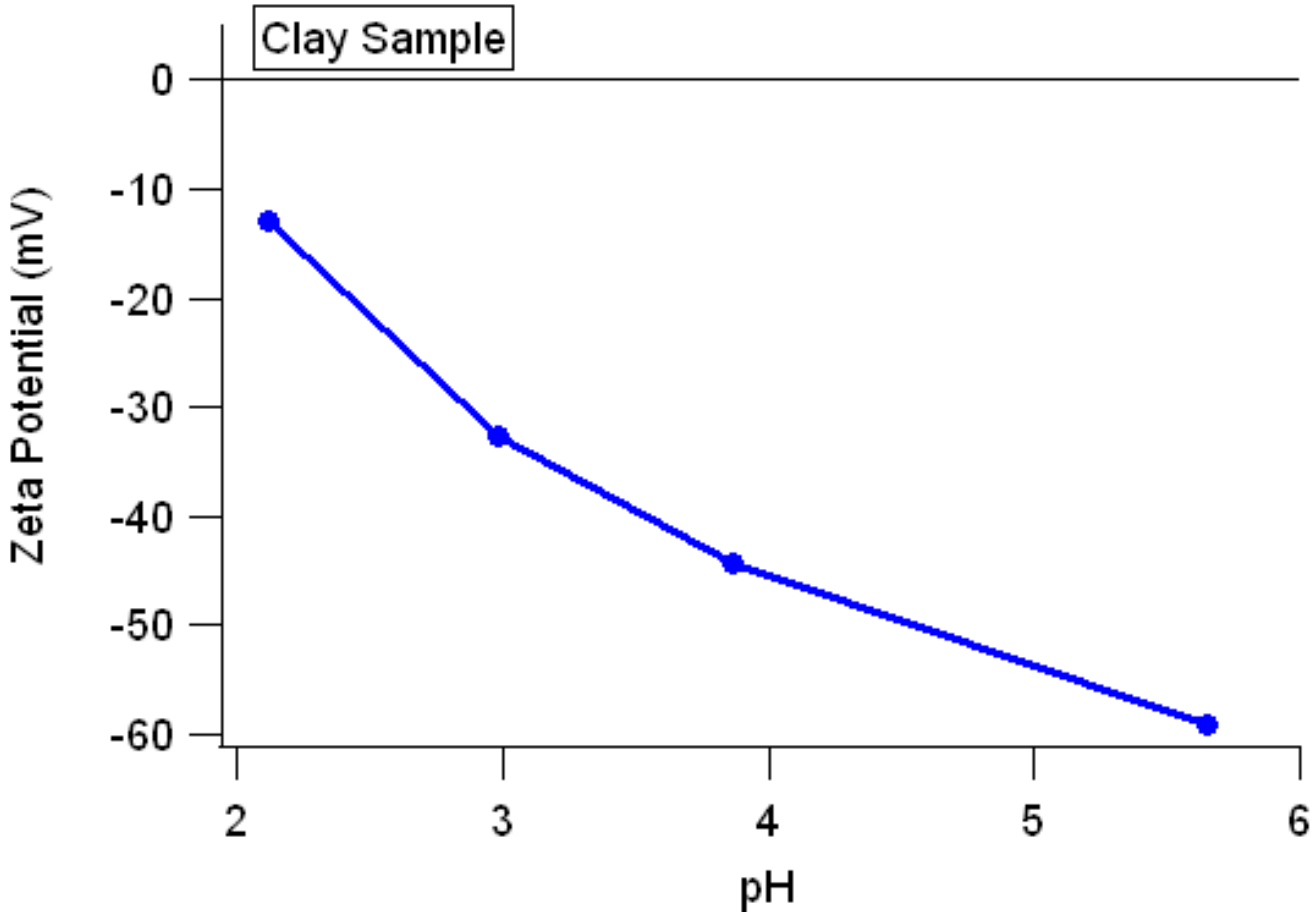
TiO_2 Grades

HORIBA



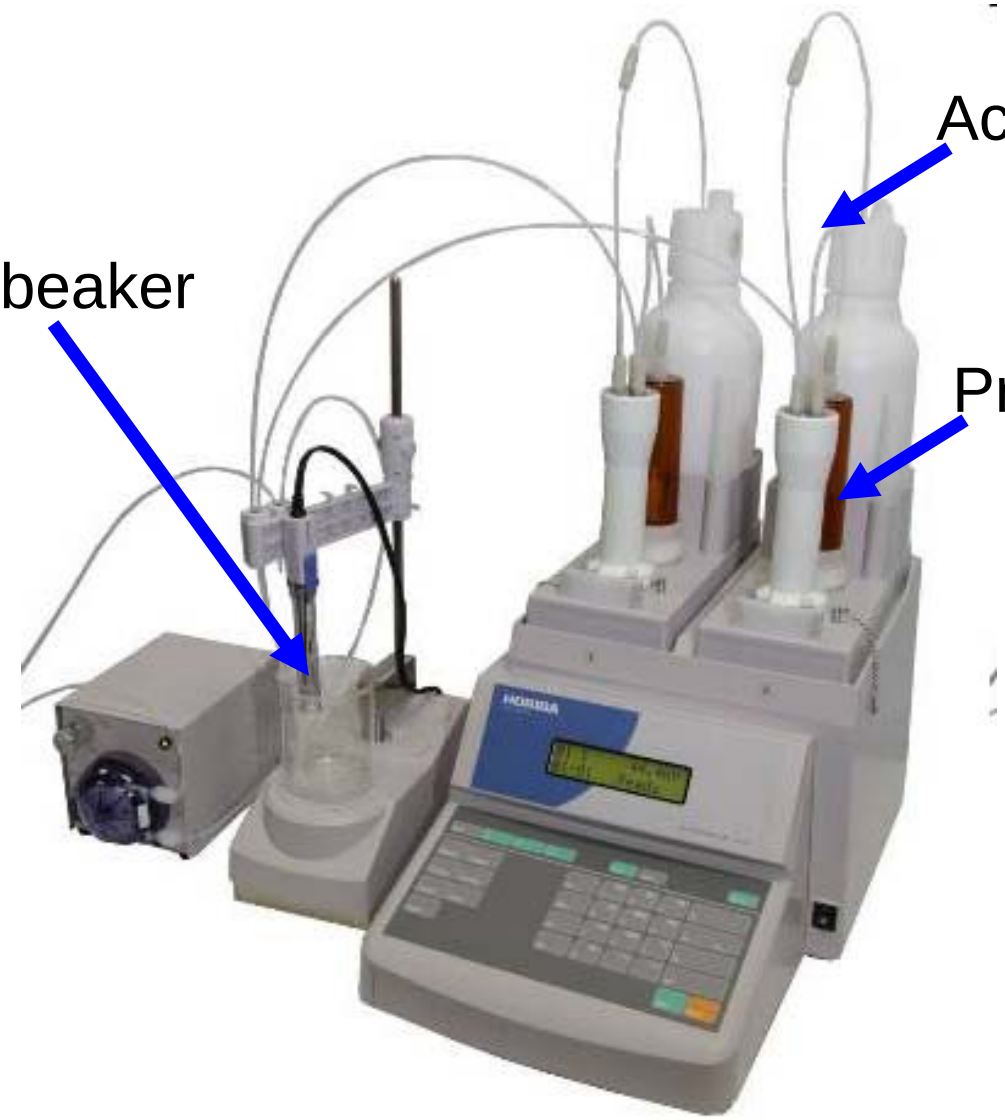
Surface matters, not bulk material

Clay



To flocculate this clay so it settles, pH must be quite low. You will need a lot of acid.

Autotitrator Accessory

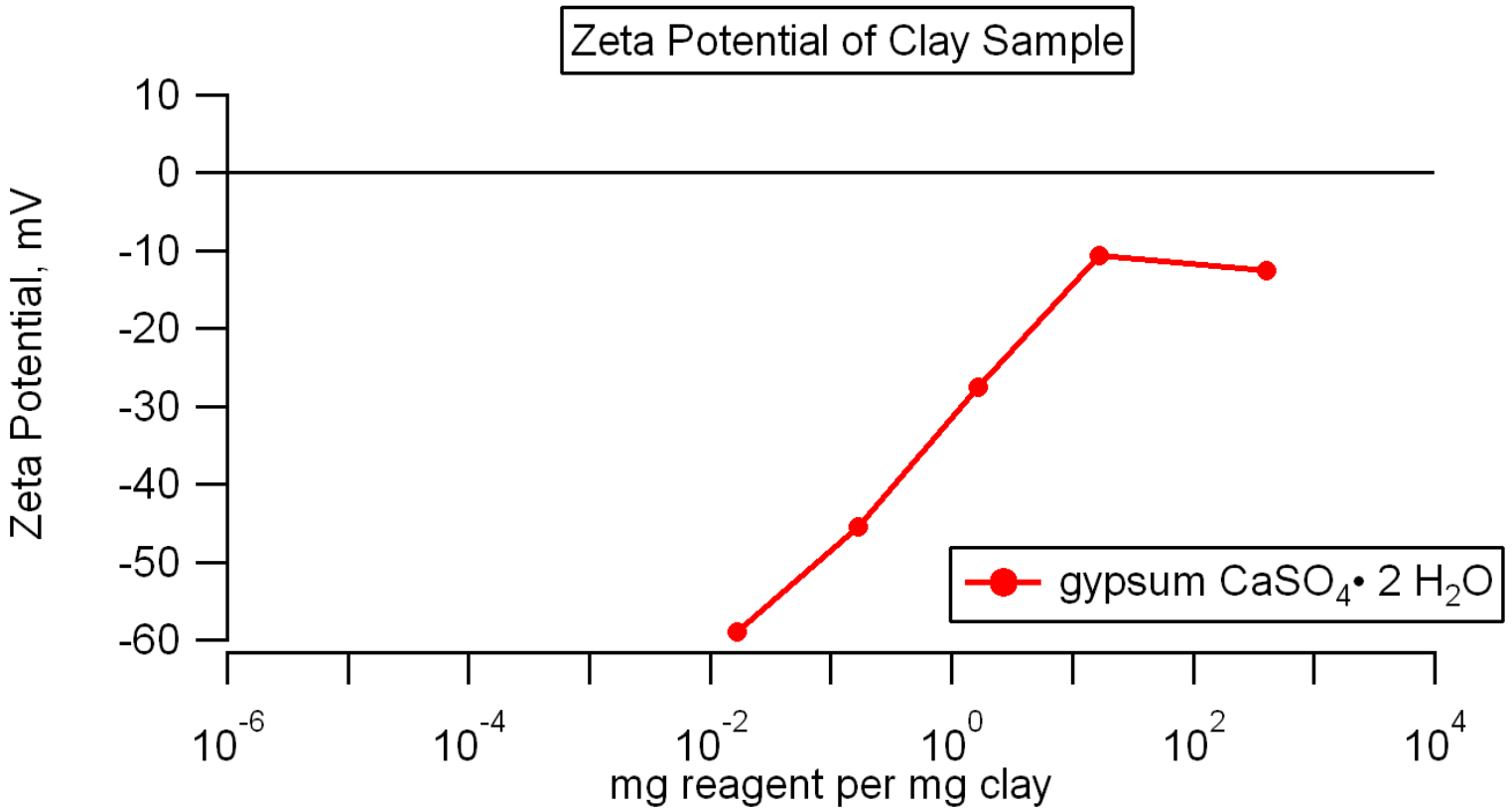


Complete SZ-100 for Zeta Potential

Industrial Control of pH

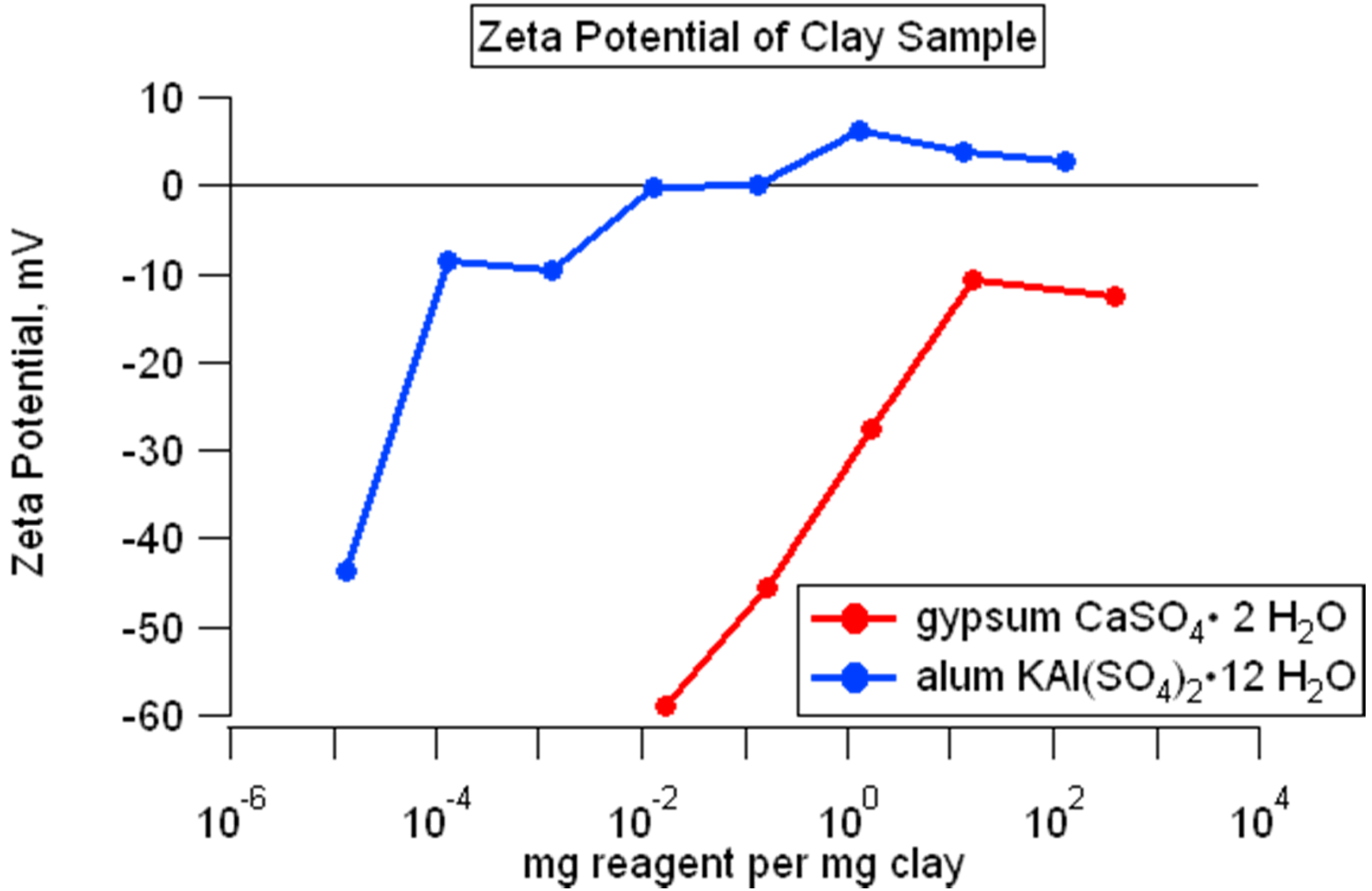
- Once you know your target pH, how do you control it in real time?
- pH controller for industrial use (HP-480 series), transmitter, 4-20 mA signal to valve to control flow of acid/base.

Other Additives: Gypsum



Note log scale

Other Additives: Alum vs Gypsum



To flocculate clay so it settles, choose alum at 0.01 g alum/g clay. Too much or too little and floculation is not ideal.

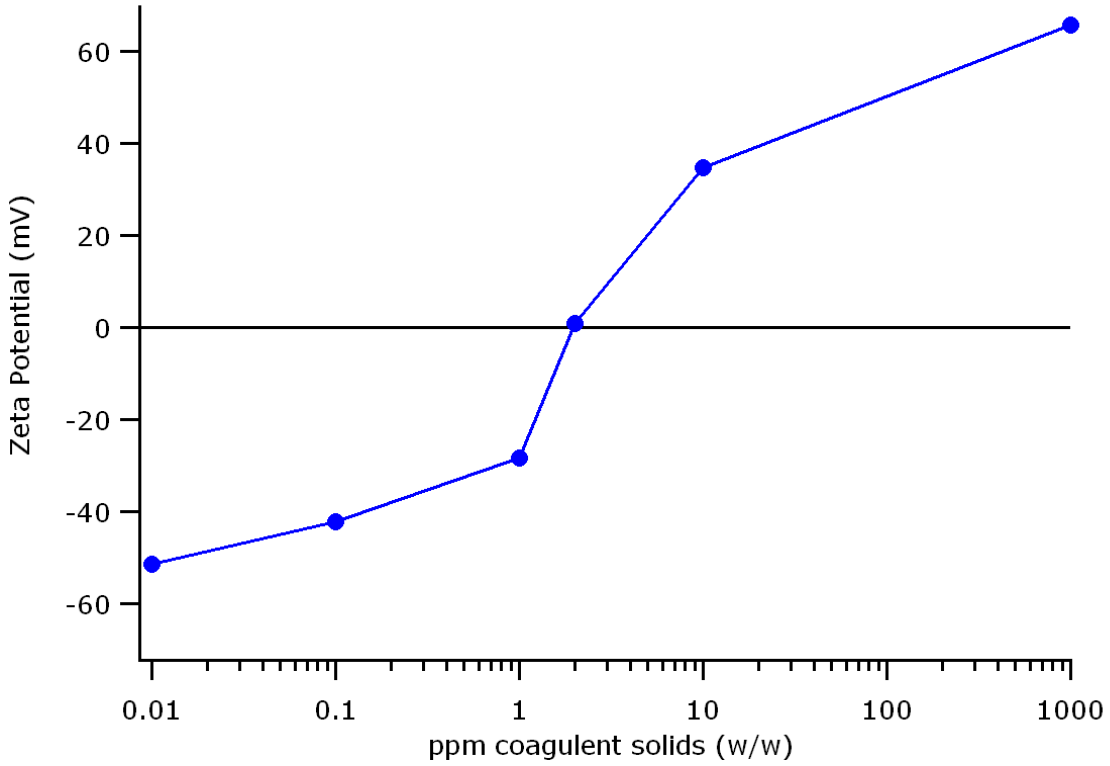
What about refinery waste?

Oil in Water such as the OCMA-350 (fast)

EPA Method 1664 oil and grease in water.
Extract with hexane. (slow, but required)

Refinery Wastewater

- Water full of oil droplets (and a bit of H_2S!)
- Unknown (proprietary) coagulent.



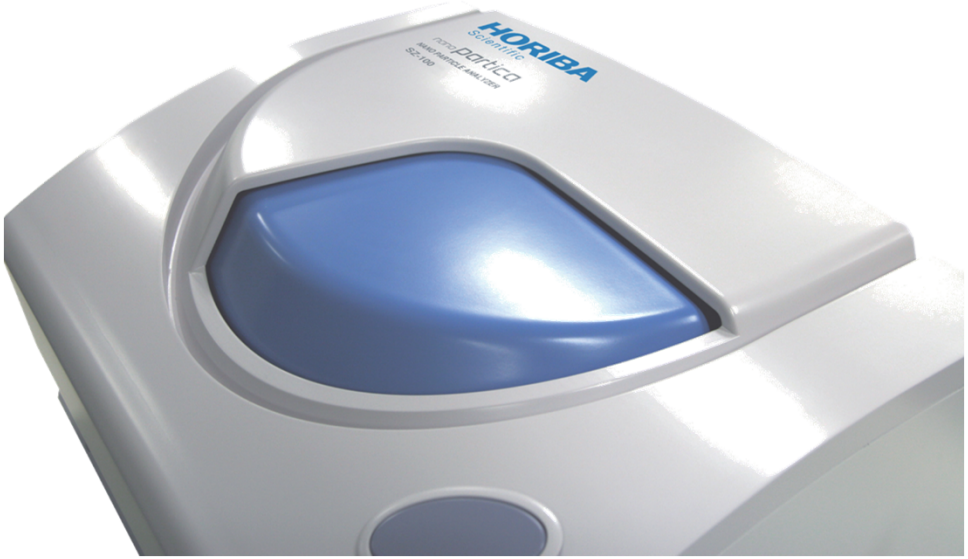
Note the strong positive charge if you add too much coagulent

Another water analysis option: The Aqualog

- The only true simultaneous absorbance-fluorescence system available
- For CDOM (colored dissolved organic matter)

Zeta Potential Conclusions

- Determining Zeta potential gives the chemist a tool for understanding what different treatment options are doing to the particles.
- Understanding is necessary for optimization.



Q&A

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Thank-you