United States Environmental Protection Agency

Preliminary Results from a Feasibility Study of the Geoelectrical Response to Select Nanomaterials in a Sand Matrix

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Objectives

- Geoelectrical response vs. nanoparticle concn. and fluid ionic strength and concn. in saturated sand columns
- Can geoelectrical methods aid nanomaterial F&T studies?

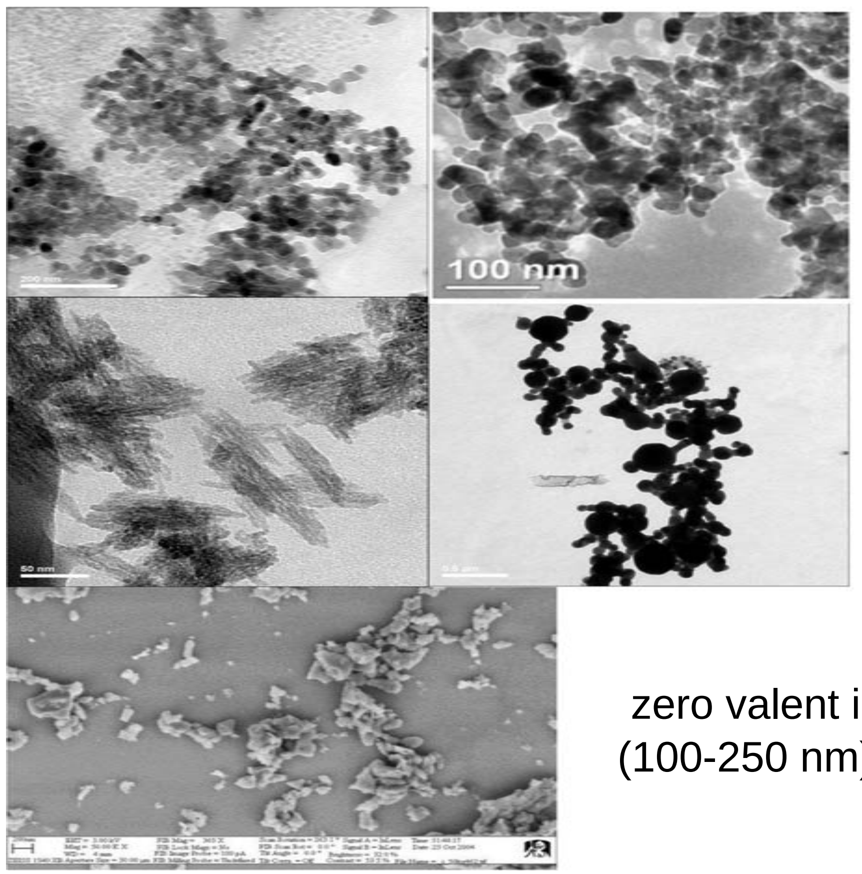
SEM images of particles used (input*) supplier = NanoAmor

cerium dioxide
(15-30 nm)

zinc oxide
(20 nm)

titanium dioxide (rutile)
(10 nm dia, 40 nm L)

silver
(90-210 nm)



zero valent iron
(100-250 nm)

agglomeration

Lab Set Up

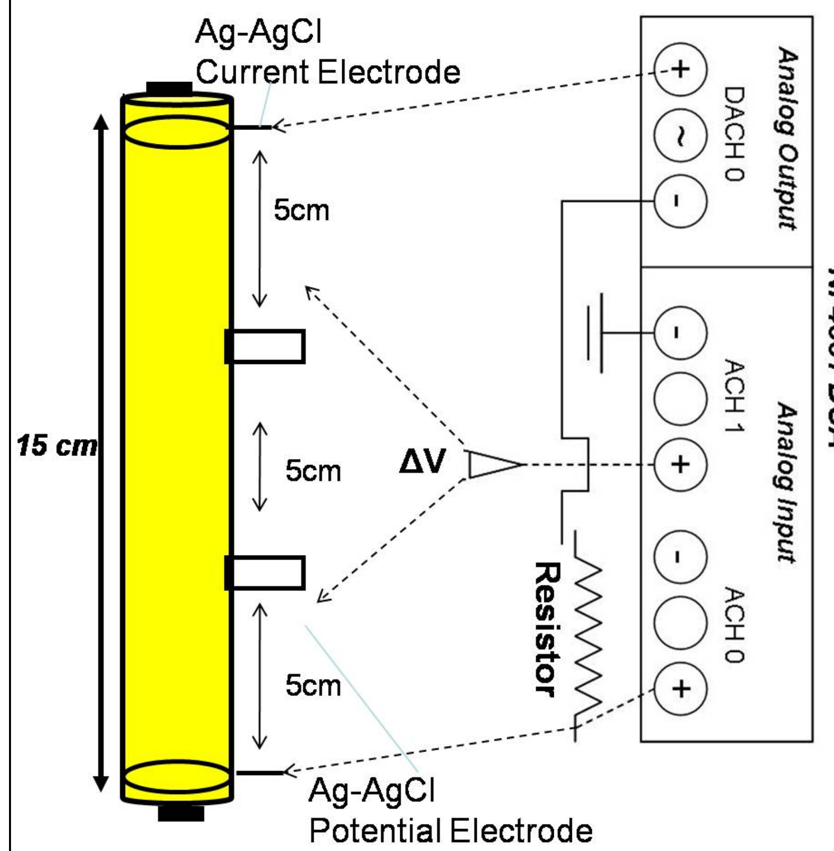
➢NI 4551 DSA and Radic Research SIPLab II instruments were used for Spectral Induced Polarization (SIP) measurements
➢Phase shift and resistivity magnitude measured at log intervals from 0.1 to 12 kHz

- Resistivity magnitude is the bulk resistivity of the entire system.
- It contains electrolytic and interfacial conductivity components.
- electrolytic is a function of fluid chemistry

✧Phase shift is a polarization term at low frequencies (<1000Hz)

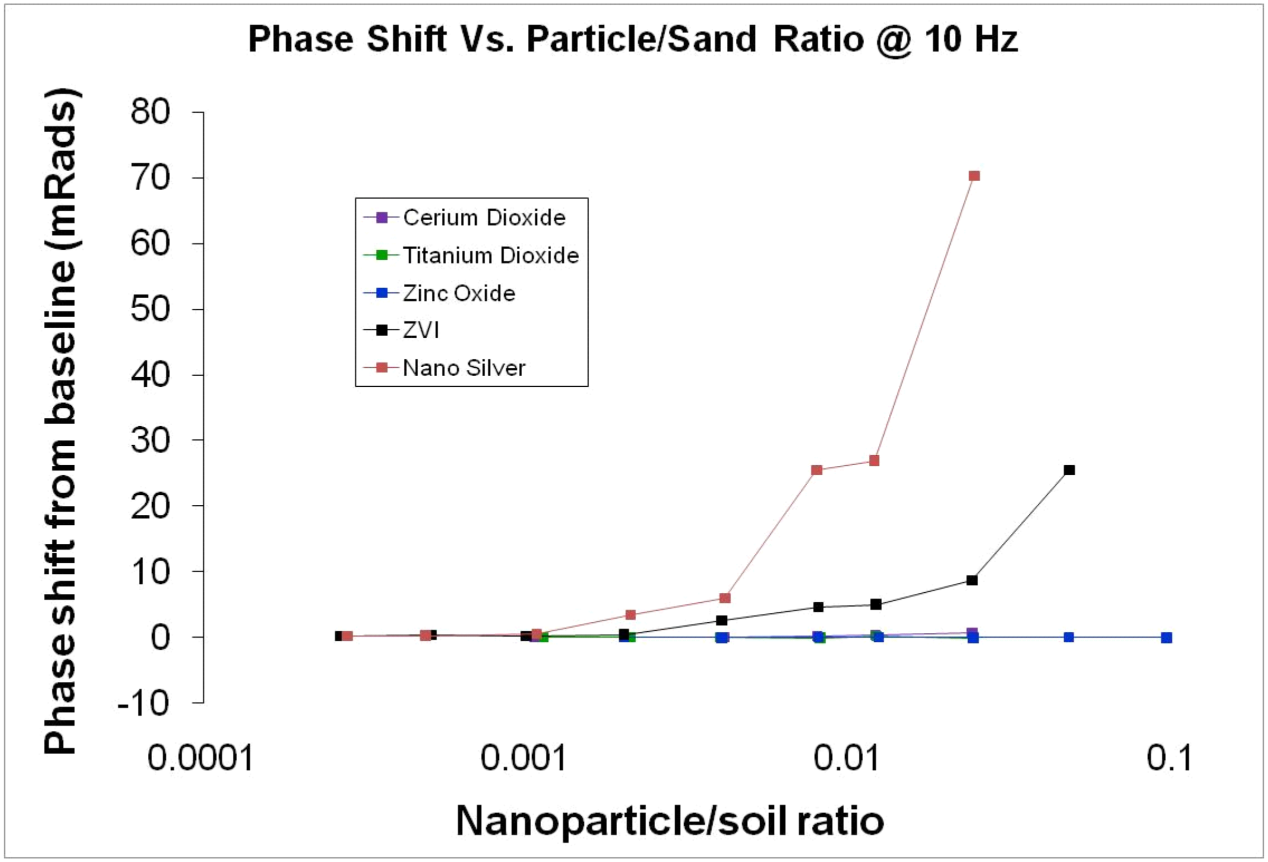
✧polarization occurs along the grain-fluid interface

✧it is sensitive to surface area, surface charge density, and ionic mobility.



Columns packed with uniform 20-30 mesh sand and the nanomaterial experimental treatment

Geoelectrical response as a function of particle concentration



- SIP is sensitive to changes in surface area within the column.
- high phase shift is expected due to the high surface area of the nanoparticles
- metallic particles show this phase response which is exacerbated due to the conductive metallic particles
- oxide nanoparticles are electrically resistive (relative to the metals).
  - conduction is primarily electrolytic showing little to no phase shift

Frequency dependence

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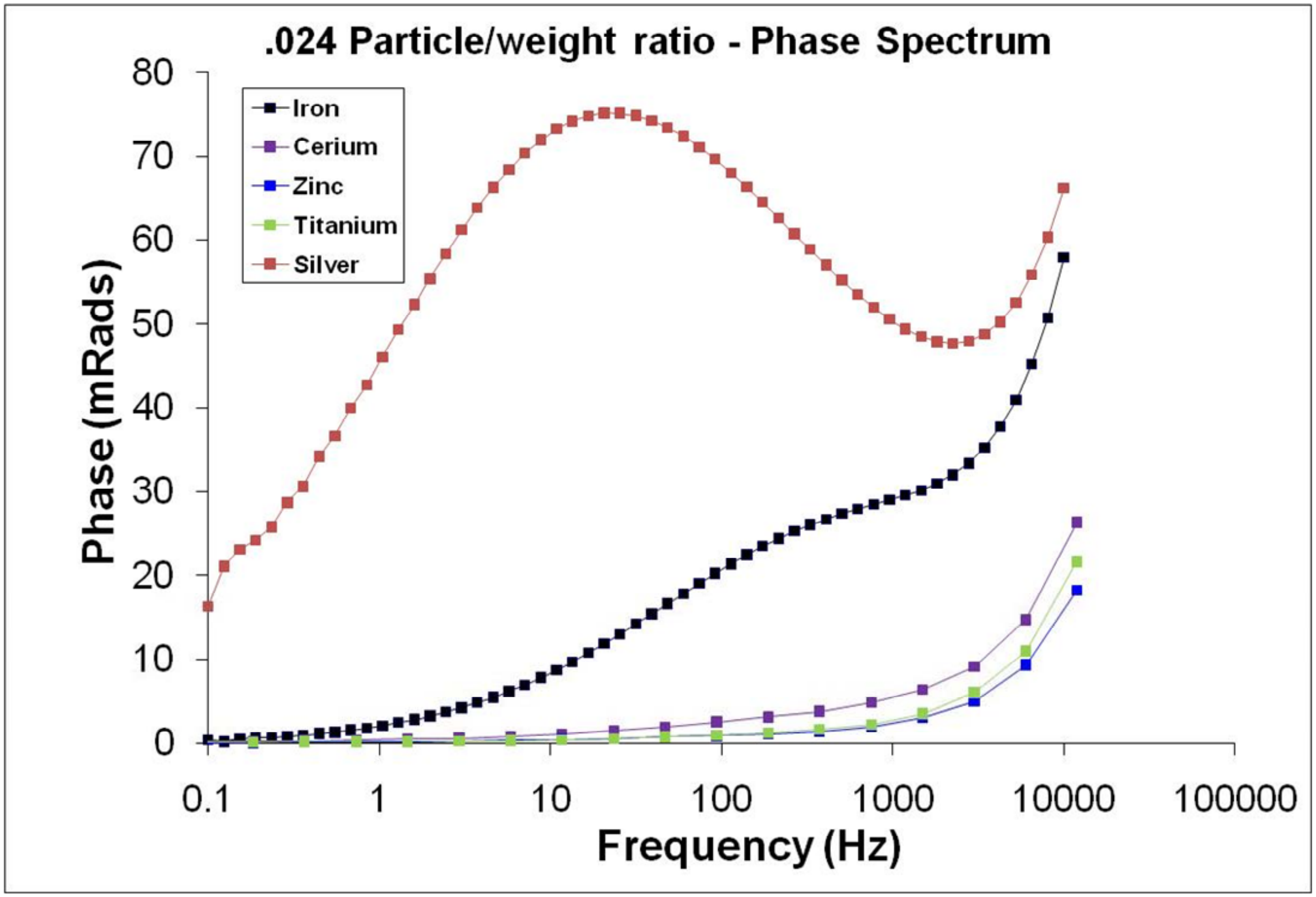
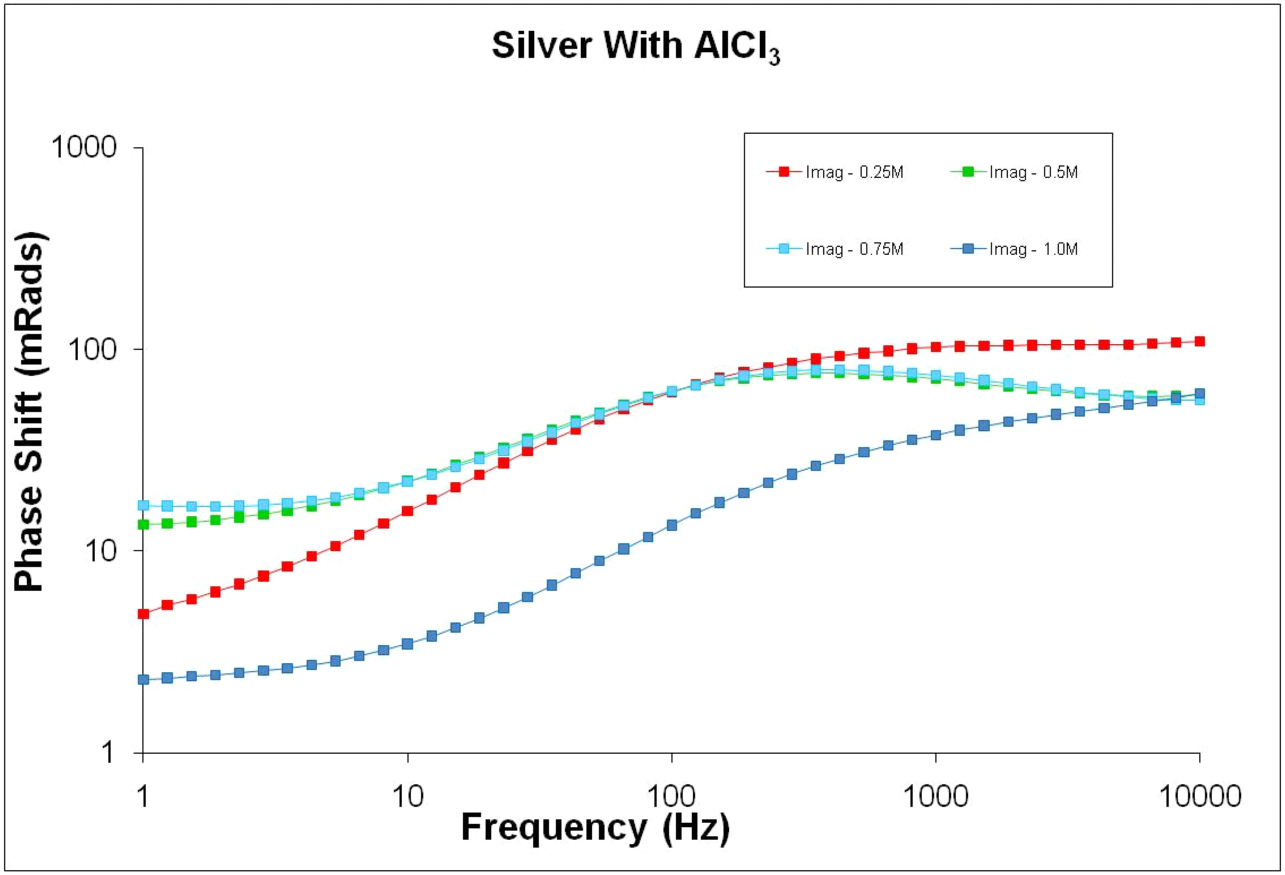


- Frequency dependence from SIP, due to resonance, is a function of particle size.
- Silver, one of the largest particle size of those tested, shows FDP at lower frequencies.
- The oxides show no response in our data. It exist at high freq; but lost in the high frequency instrumentation noise

Phase shift vs. ionic strength and conc. of the saturated fluid



- salt solutions of various ionic strengths (+1, +2, +3) and molarities were tested.
- shown above, the aluminum chloride solutions show silver with a frequency dependent response.
- the response appears due to fluid conductivity concn..
- higher fluid concn. the response shifts toward higher frequencies and a lower phase shift suggesting electrolytic conduction is superseding the polarization effect.

Conclusions

- The oxide particles do not show a significant response relative to background
- It may be possible to detect nano silver and ZVI if they existed in high enough concentrations.
  - The electrical properties of these particles are very responsive to electrical geophysical methods.
- For silver, the conc. of the ionic fluid reduces the phase shift suggesting a highly ionic pore fluid may mask the silver polarization effect.
- Further experiments are planned to investigate the effects of;
  - varying surface area in the nanoparticles,
  - the nanoparticles response under varying redox conditions,
  - microbial interactions,
  - the seismic response to nanoparticles
  - introduce more complex geology (matrices)