Effects of pH, Electrolyte Concentration and Organic Acid Coating on the Aggregation Kinetics of Hematite Nanoparticles

Pearl Chen

Dr. John Lenhart, Wei Zhou, Liz Whalen

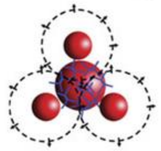
The Ohio State University

Department of Civil, Environmental and Geodetic Engineering

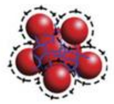
Introduction and Background

- Ionic strength: salt compresses electrical double layer, repressing repulsive forces

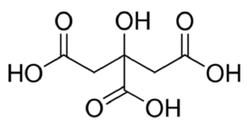
Low ionic strength



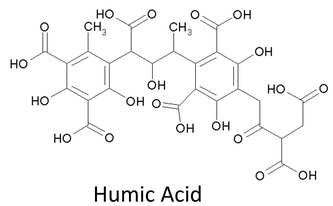
High ionic strength



- Presence/concentration of organic acid: research suggests low acid concentrations enhance aggregation, while high acid concentrations result in more stable solutions



Citric Acid



Humic Acid

- pH: hematite is amphoteric, meaning it can act as an acid or base

Hypothesis

Low acid concentrations: stability will decrease (lower CCC)
High acid concentration: stability will increase (higher CCC)
pH < 7: Acid will adsorb to hematite and increase stability
pH > 7: Less acid will adsorb and the solution will aggregate more quickly

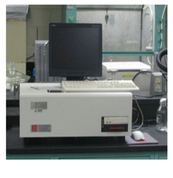
Procedure

50 nm-sized hematite particles were synthesized following Lenhart *et al.*[1]

15 g/L hematite and acid in citric acid experiments

Varying concentrations of NaCl (0.001-0.2 M) and acid in humic acid experiments

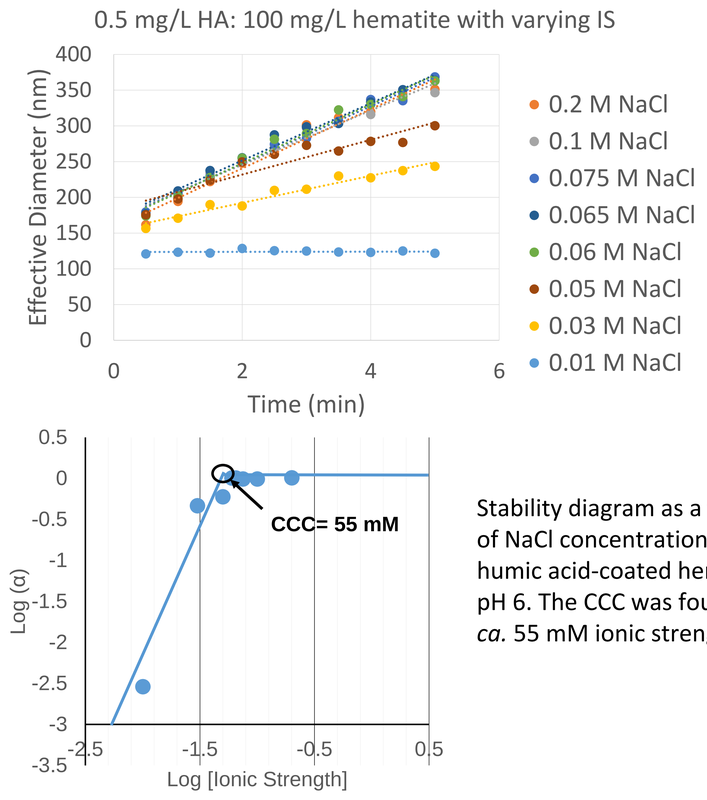
Rapid hand-shake



DLS

Results

Critical Coagulation Concentration (CCC): ionic strength at which when particles collide, coagulation will always occur



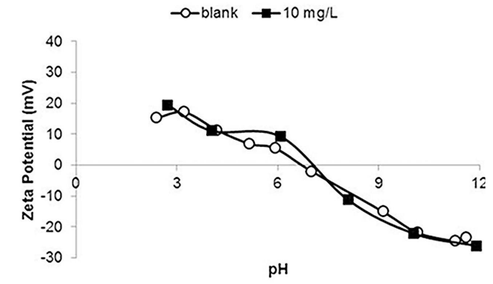
Stability diagram as a function of NaCl concentration for humic acid-coated hematite at pH 6. The CCC was found to be *ca.* 55 mM ionic strength.

Critical Coagulation Concentration (CCC) in mM NaCl					
	pH				
	4	5	6	8	9
Bare hematite	72	63	32	Unstable	Unstable
1.92 mg/L citric acid: 100 mg/L hematite	11	10	3.5	19	47
19.21 mg/L citric acid: 100 mg/L hematite	X	X	10	82	56
38.42 mg/L citric acid: 100 mg/L hematite	13	56	79	X	X
384.25 mg/L citric acid: 100 mg/L hematite	11	58	Unstable	X	X
0.5 mg/L humic acid: 100 mg/L hematite	X	X	55	X	X

Conclusions

- Effects on pH were consistent with hypothesis:
  - At low pH, bare hematite was stable and stability decreased with acid coating
  - At high pH, bare hematite was unstable and stability increased with acid coating

- Data corresponds to the Point of Zero Charge (PZC) for hematite[2]



- Effect of acid concentration was dependent on pH
  - Higher pH = larger acid concentrations led to greater stability
  - Lower pH = acid coating led to less stability, but for pH 5, effect was smaller with more acid

- Humic acid coating had comparable effect on hematite stability as citric acid coating with 70x smaller concentration

References

[1]Lenhart JJ, Heyler R, Walton EM, Mylon SE (2010) The influence of dicarboxylic acid structure on the stability of colloidal hematite. Journal of Colloid and Interface Science, Volume 345, Issue 2, 2010, 556–560.

[2]Alexandrino, Júnia Soares, Peres, Antônio Eduardo Clark, Lopes, Gilmara Mendonça, & Rodrigues, Otávia Martins Silva. (2016). Dispersion degree and zeta potential of hematite. Rem: Revista Escola de Minas, 69(2), 193-198.

Acknowledgements

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