Iron-Based Remediation: Oxidative Platform

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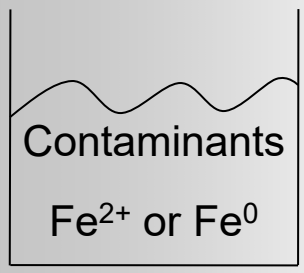
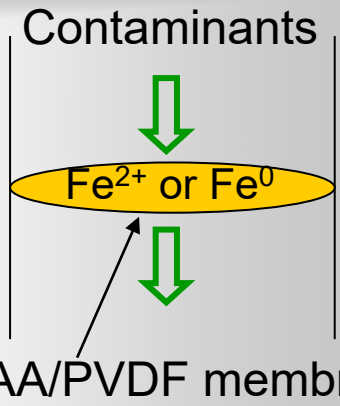


Fe^{2+} / Fe^{3+}



Solution-Phase

Membrane-Immobilized

Reduction

Oxidation

Green Synthesis

Fe^0

Aggregate NPs

Bulk

$Fe(II,III) + H_2O_2$

$Fe_xO_y + H_2O_2$

$Fe^0/Fe_xO_y + H_2O_2$

Iron Nanoparticle Injection Field Study

- Fe/Pd nanoparticles - CMC coated (0.5 wt%)
  - Prepared on-site
  - 0.1 wt% Pd
- Rapidly degraded TCE, PCE
- Boosted biological dechlorination over long-term
- Tracer: Br^-

- Unconfined aquifer
  - Hydraulic conductivity = 5.6 ft/day
  - Seepage velocity = 0.22 ft/day
- Injections 45-50 ft underground
- ~600 days monitoring
- Injection 1: 01/29/2007
  - ~120g Fe/Pd nanoparticles (~180 gal)
- Injection 2: 02/26/2007
  - ~180g Fe/Pd nanoparticles (~38 gal)

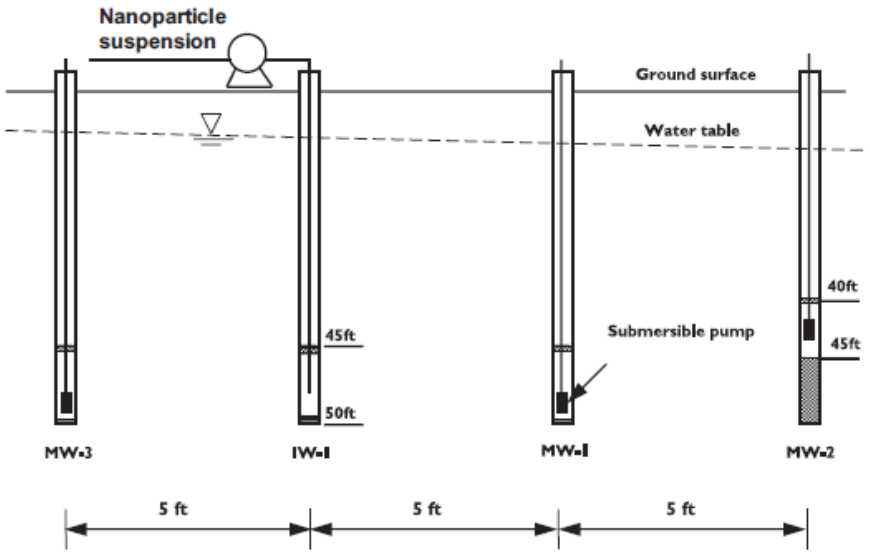
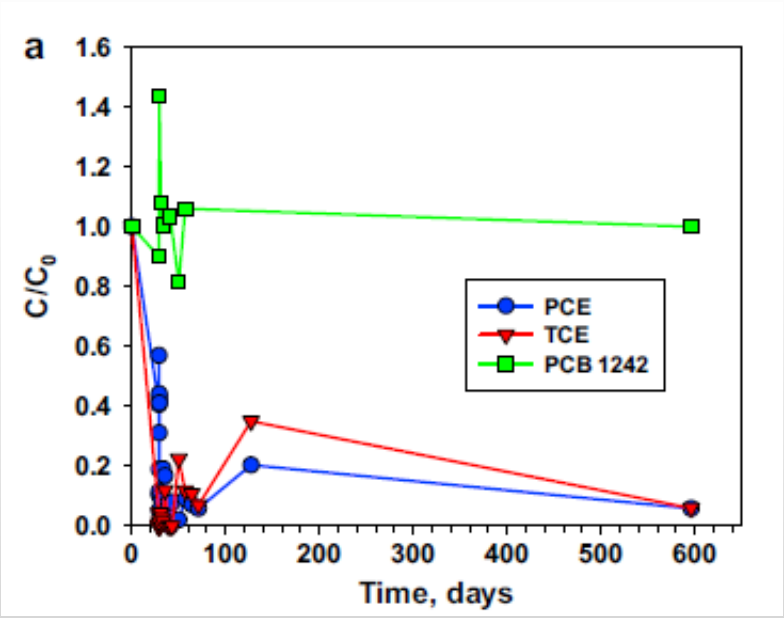


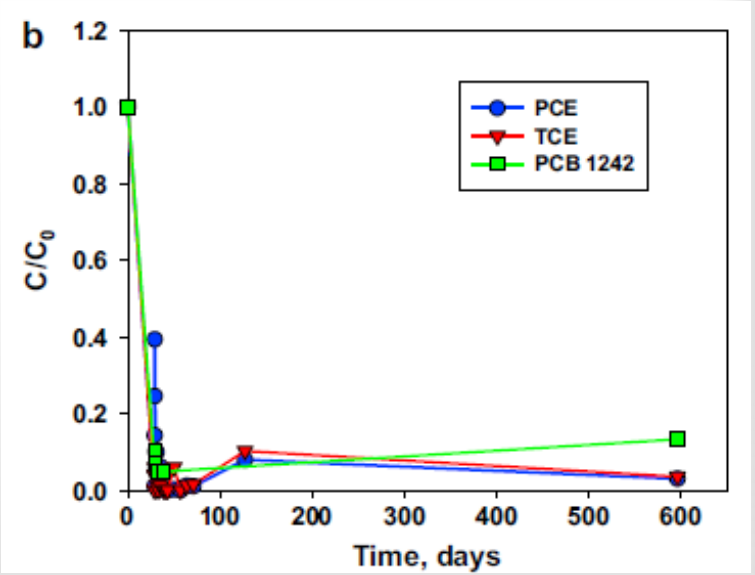
Fig. 1 – A sectional view of the aquifer at the testing site and schematic of the in situ injection of CMC-stabilized Fe–Pd nanoparticles.

He, F.; Zhao, D.; Paul, C. Field assessment of carboxymethyl cellulose stabilized iron nanoparticles for in situ destruction of chlorinated solvents in source zones. *Water Research* 44 (2010) 2360-2370.

Iron Nanoparticle Injection Field Study

- TCE, PCE degradation





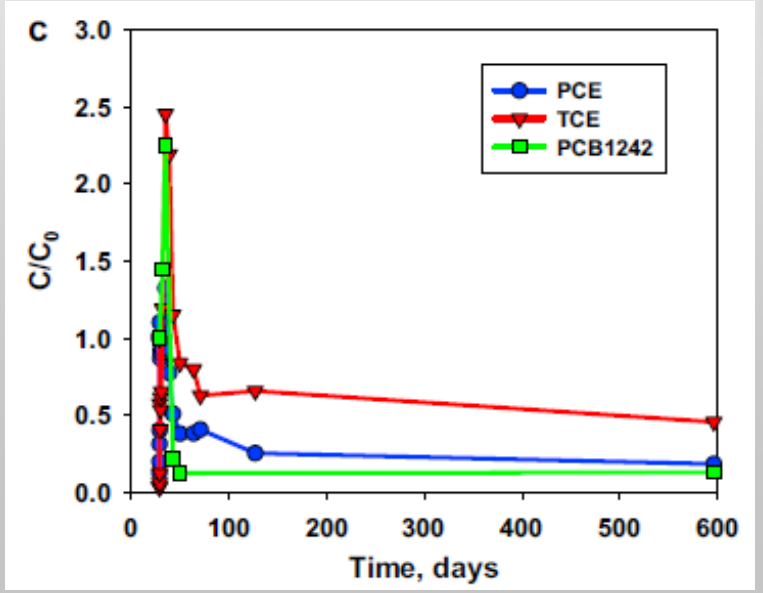
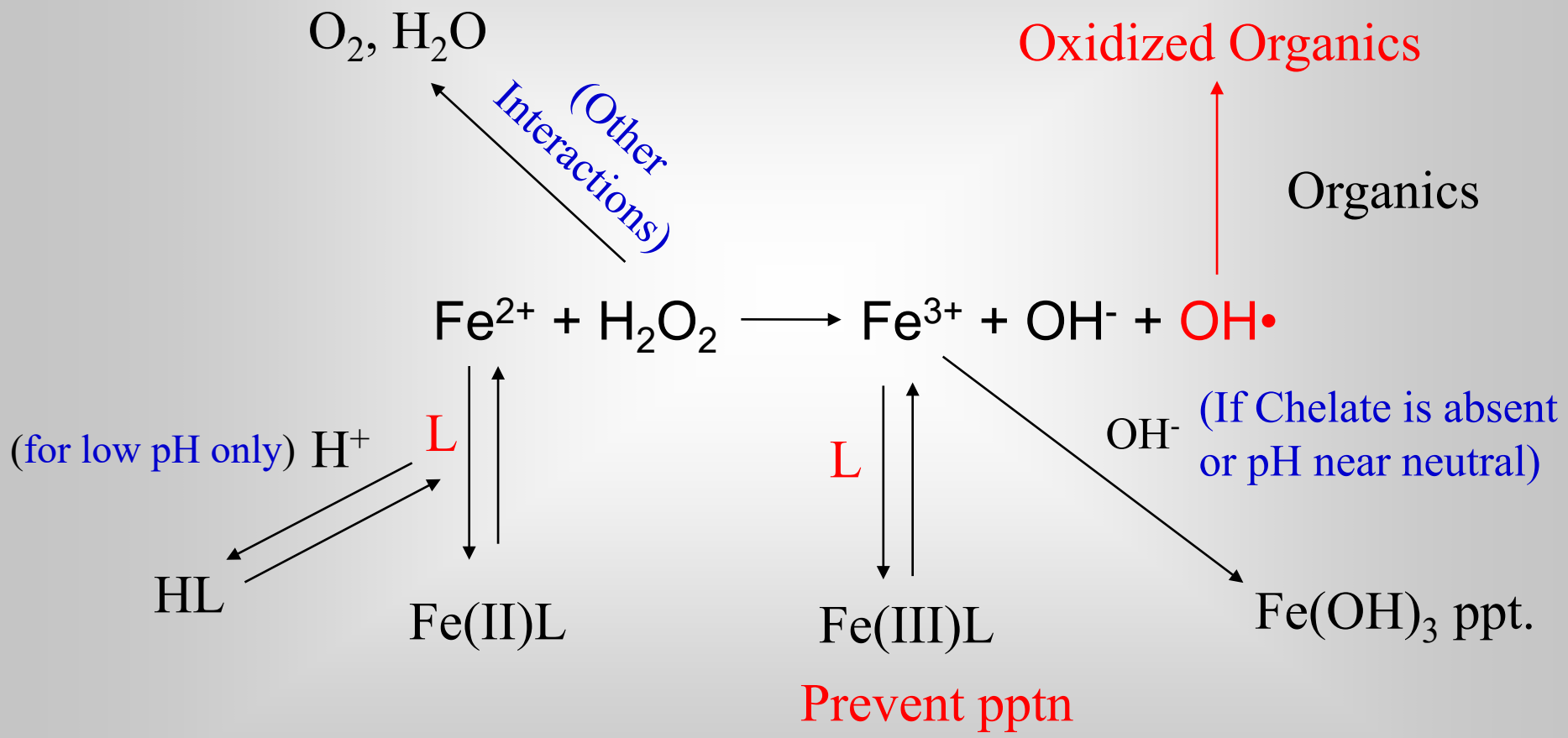


Fig. 7 – The long-term concentration histories of PCE, TCE and PCB1242 in groundwater from MW-1 (a), MW-2 (b), and IW-1 (c). The pre-injection concentrations of PCE, TCE, and PCB1242 in IW-1 were 11765 ppb, 7403 ppb and 97 ppb, respectively.

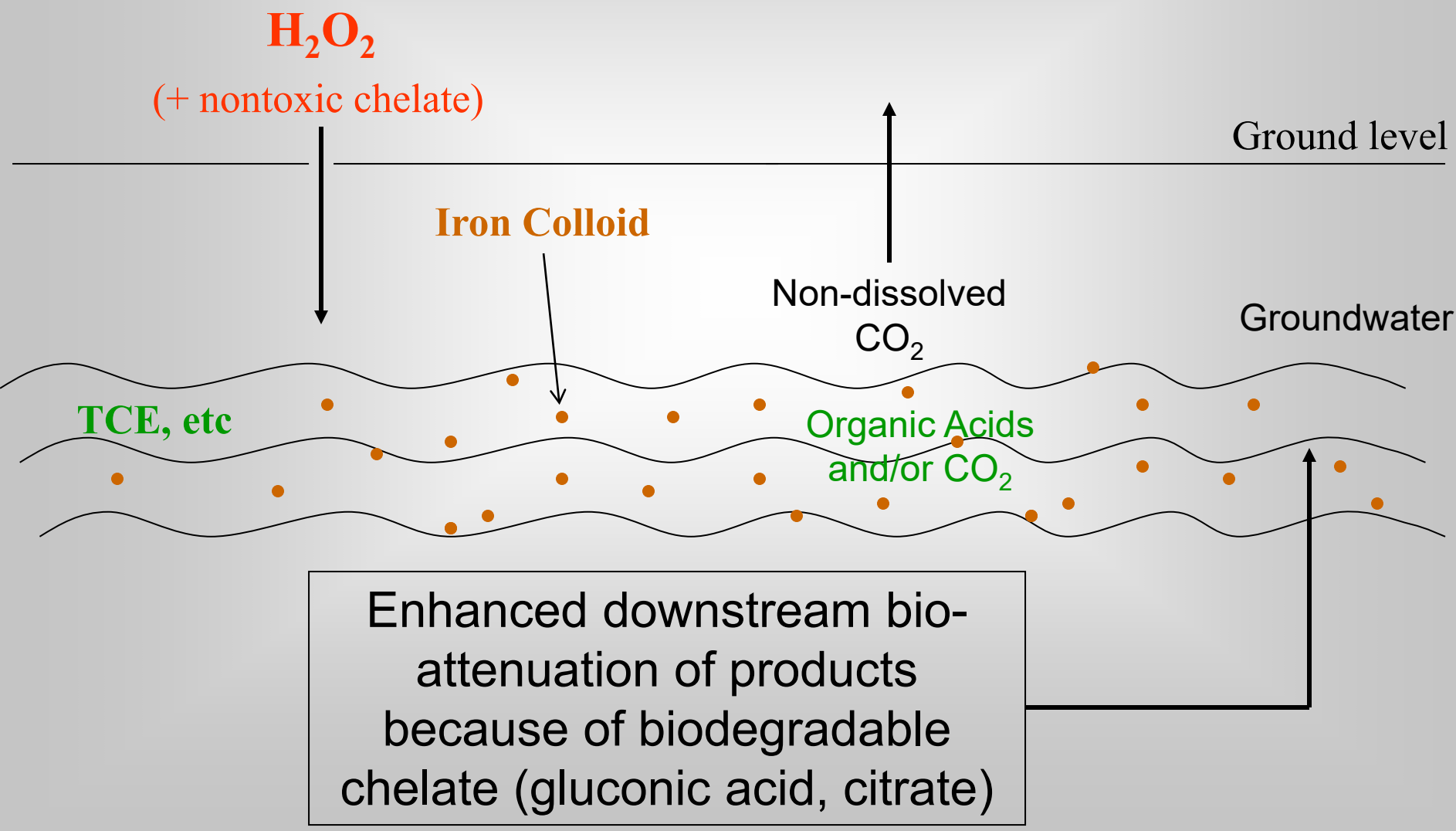
He, F.; Zhao, D.; Paul, C. Field assessment of carboxymethyl cellulose stabilized iron nanoparticles for in situ destruction of chlorinated solvents in source zones. *Water Research* 44 (2010) 2360-2370.

Modified Fenton Reaction Pathway at Neutral pH

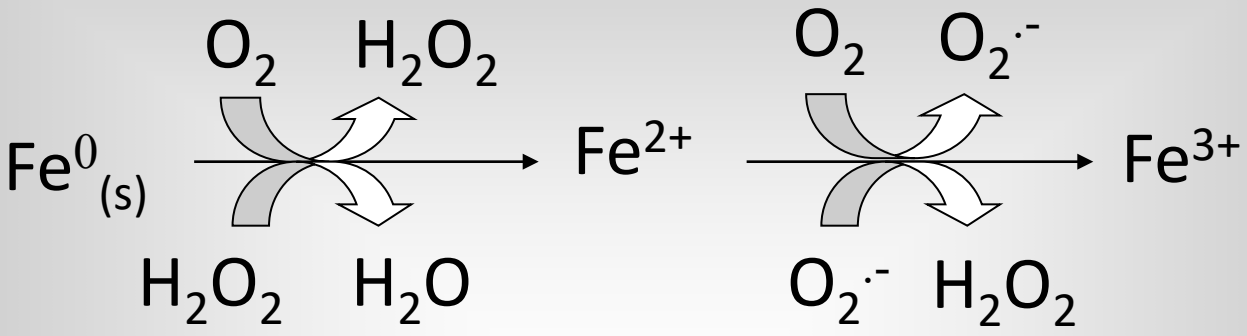


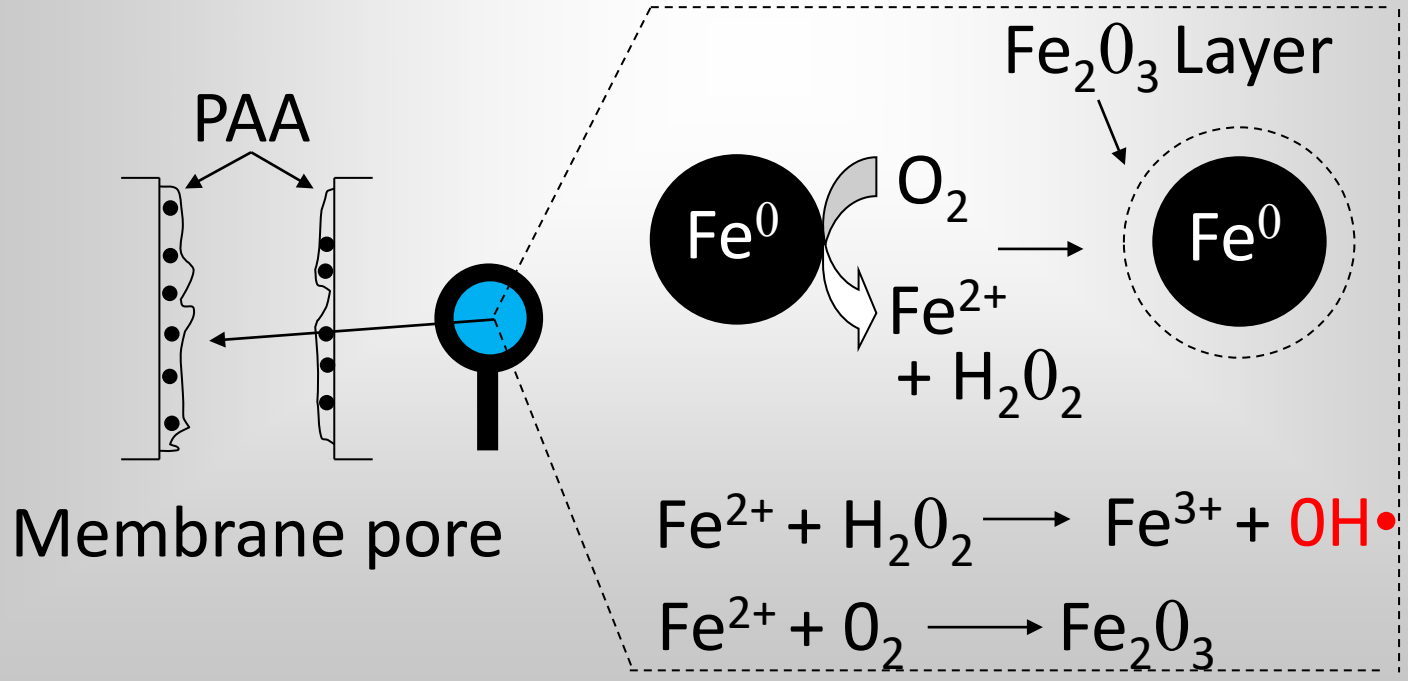
Taking Advantage of Natural Iron Colloids

No nanoparticle injections necessary



Fe^0 Nanoparticle-Based Oxidant Production

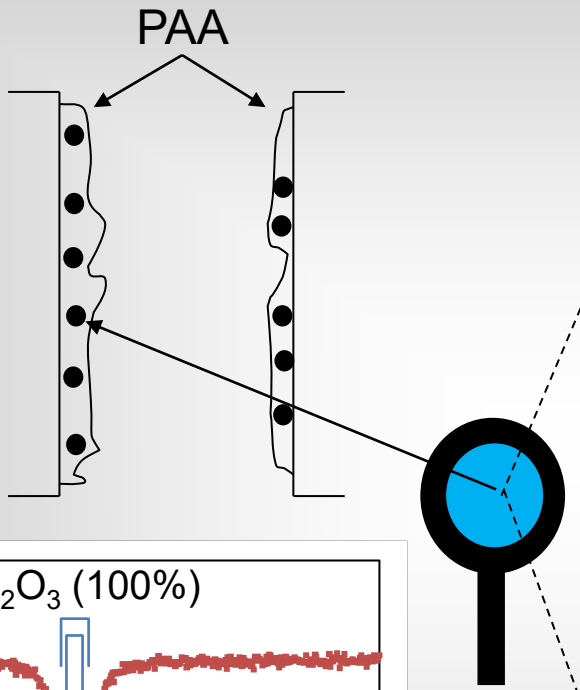


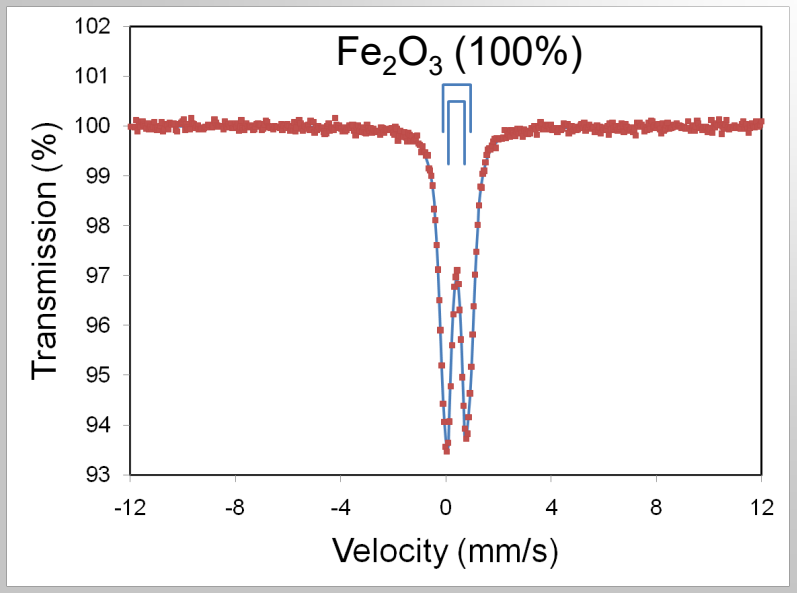


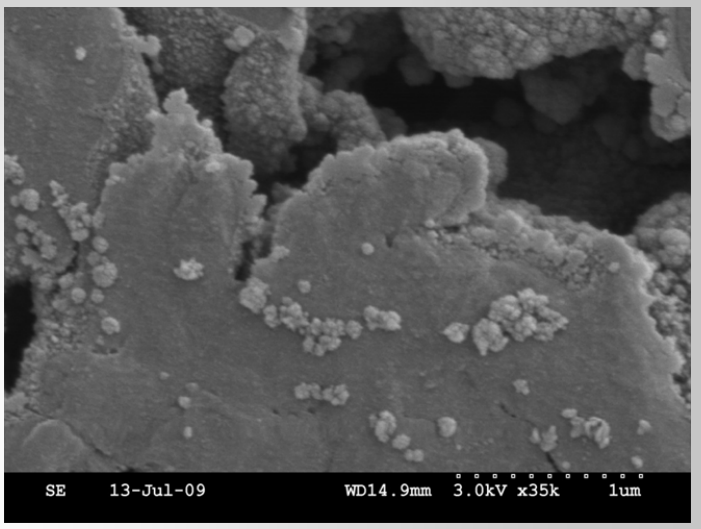
Adapted from: Keenan, C. R. and D. L. Sedlak (2008). Env Sci & Tech **42**(18): 6936-6941.

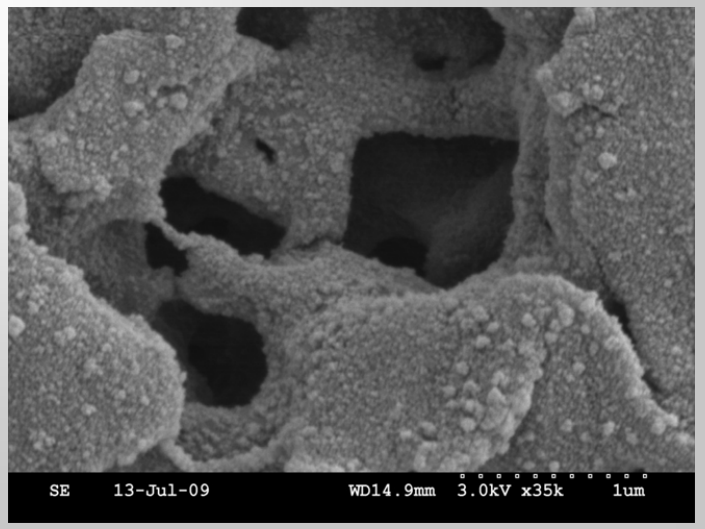
Fe_2O_3 Nanoparticle Formation in Membrane Pore

Membrane Pore

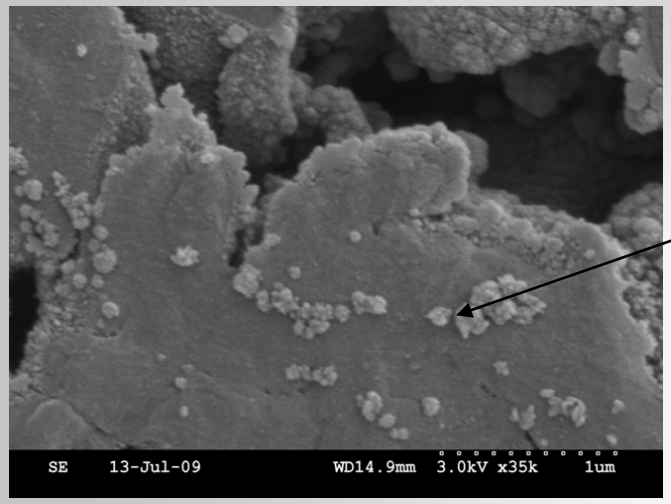


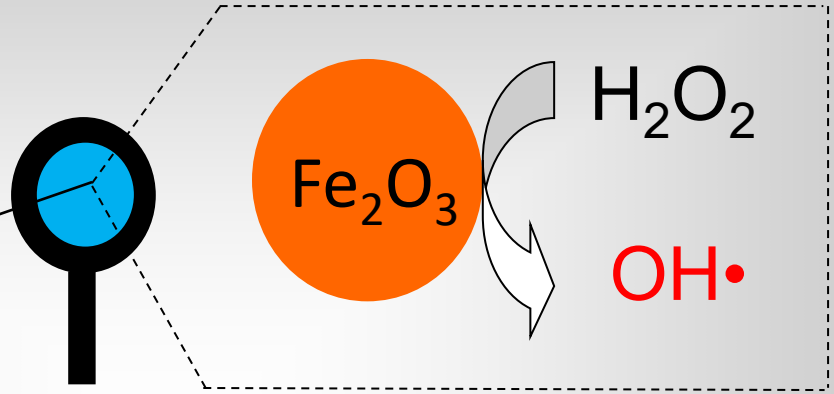






Fe_2O_3-Catalyzed Decomposition of H_2O_2





Comparison of 2-CP oxidation and adsorption after 6 h by various iron oxides.

Iron Oxide	Granular Ferrihydrite	Goethite α-FeO(OH)	Hematite α-Fe_2O_3
Surface Area (m^2/g)	190	39.5	9.15
Oxidized (%)	3.2	8.4	14.9
Adsorbed (%)	1.3	3.3	7.2

$[H_2O_2]_0$ = 9.8 mM; [Iron Oxide] = 1 g/L; $[2\text{-CP}]_0$ = 15 mg/L

Adapted from Huang *et al.* (2001) Water Res. **35** (9): 2291-2299