Magnetismus nanočástic oxidů železa

Jiří Tuček

Regionální centrum pokročilých technologií a materiálů, Přírodovědecká fakutla, Univerzita Palackého v Olomouci,
email: jiri.tucek@upol.cz, www.rcptm.com

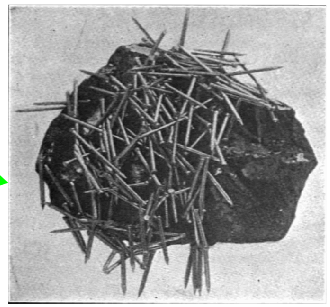
1. History of iron oxides

Iron oxides → a magnet → rise of new branch of physics → MAGNETISM

1st records:

- **Ancient Mesopotamia: iron oxides used in weights from the late third millenium BC (different iron ores such as magnetite for making cylinder seals from 2000 BC).**
- **In Ancient Mesopotamia, magnetite referred to as „grasping hematite“ („shadanu sabitu“) in a list of commodities.**
- **Properties of magnets: Greece → 6th century BC, Thales of Miletus (c. 640-546 BC): „A magnet has a soul“.**
- **The name „magnet“: 1st centrury BC, Lucretius (95-55 BC).**

Magnesia (province in Asia Minor) → lodestone (magnetite) → magnetism

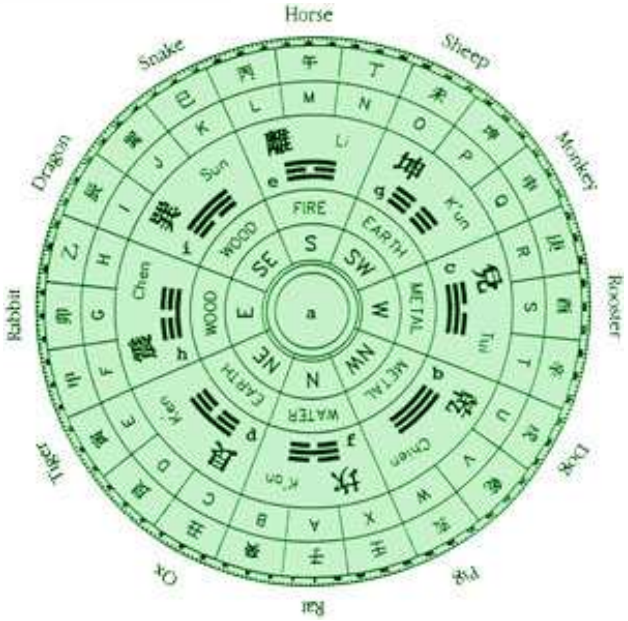


Applications: 83 AD → South-pointing spoon (China, Lun Heng: „Discourses Weighted in the Balance); 1080 AD → Chinese description of magnetic needle compass.

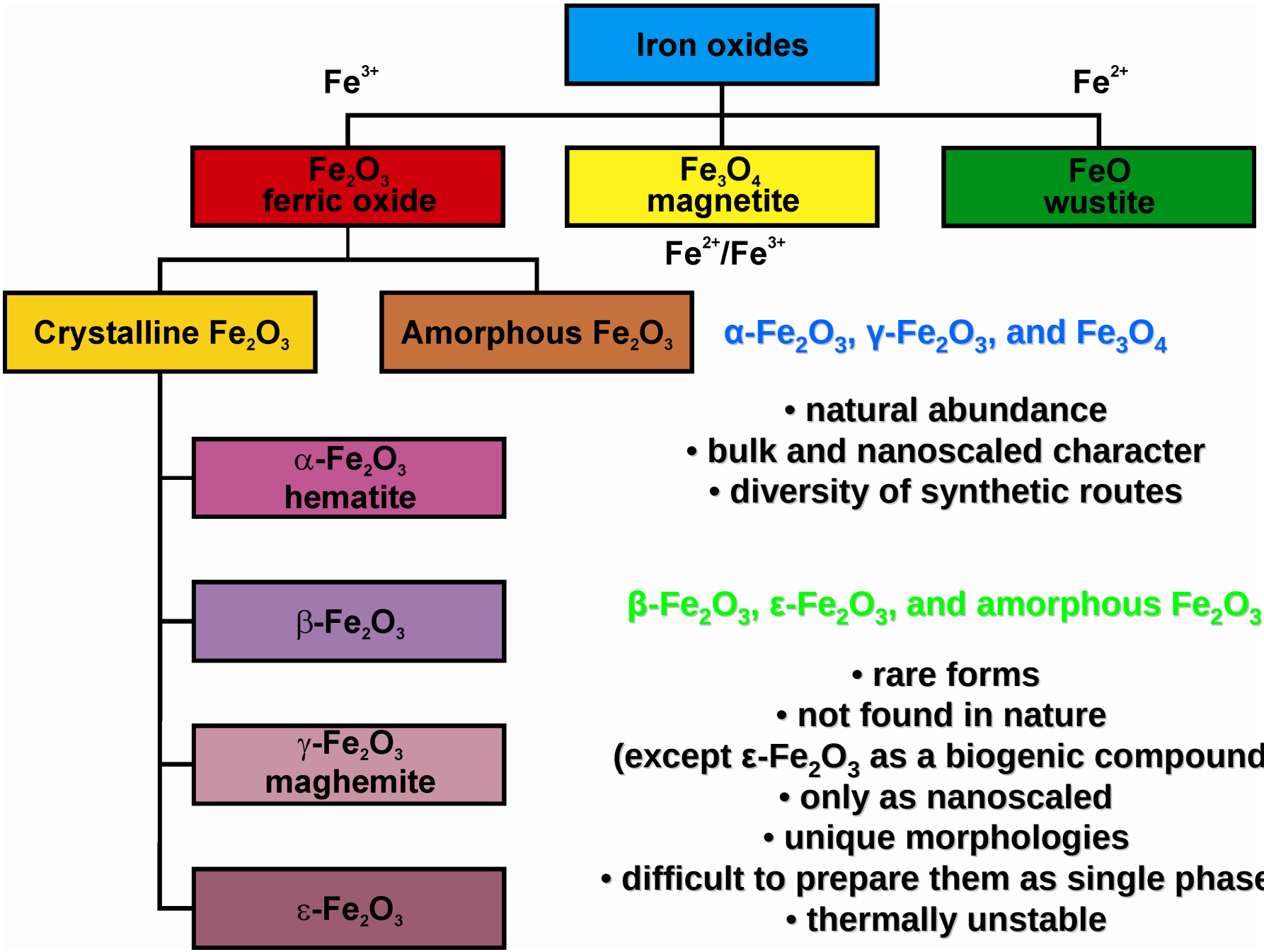
1. History of iron oxides

South-pointing spoon (from lodestone)

Magnetic needle compass
(needle from lodestone and/or iron)



2. Current classification of nonhydrated iron oxides



α-Fe_2O_3, γ-Fe_2O_3, and Fe_3O_4

- natural abundance
- bulk and nanoscaled character
- diversity of synthetic routes

β-Fe_2O_3, ε-Fe_2O_3, and amorphous Fe_2O_3

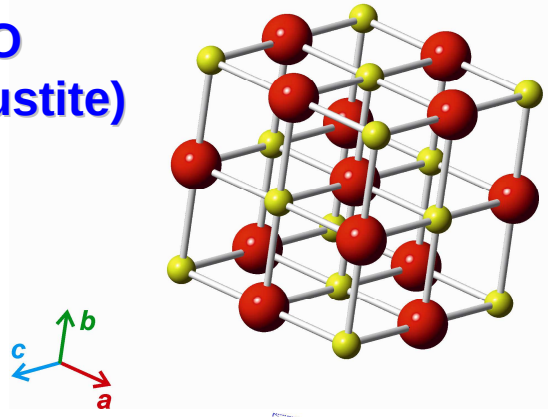
- rare forms
- not found in nature

(except ε-Fe_2O_3 as a biogenic compound)

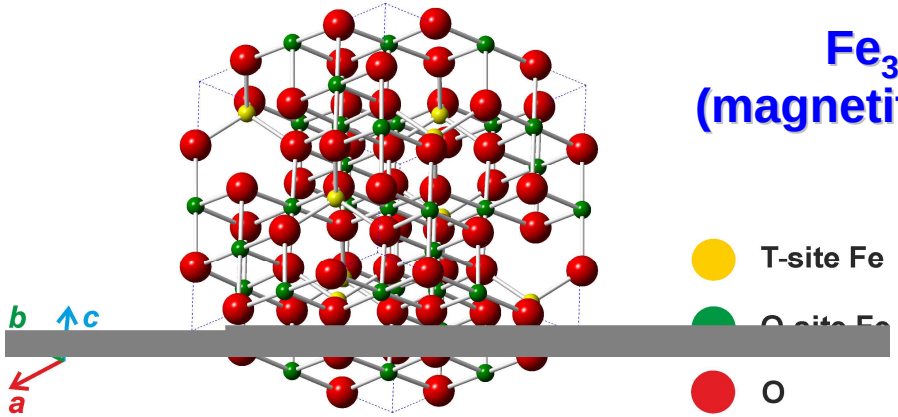
- only as nanoscaled
- unique morphologies
- difficult to prepare them as single phases
- thermally unstable

2. Current classification of nonhydrated iron oxides

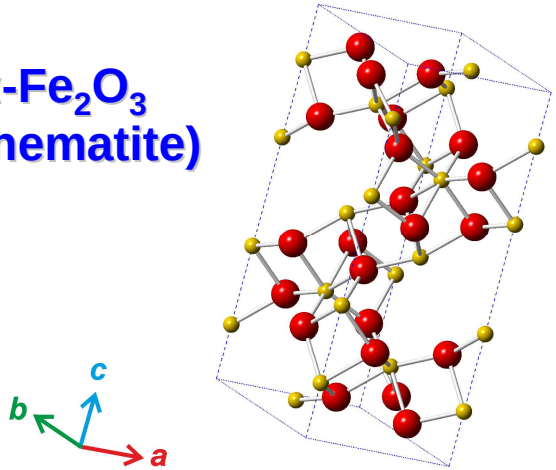
FeO (wustite)

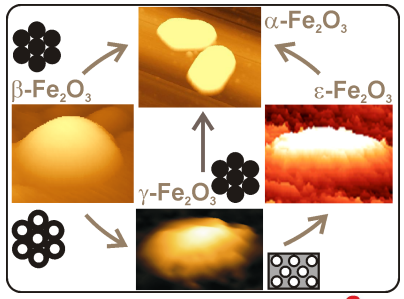


Fe_3O_4 (magnetite)

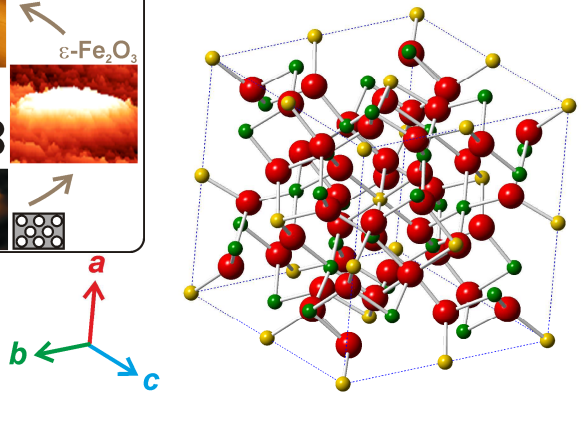


α-Fe_2O_3 (hematite)

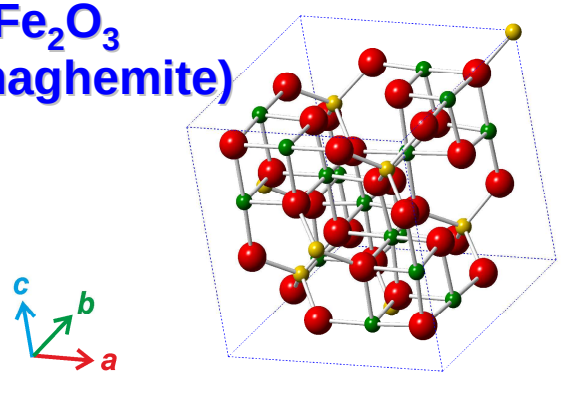




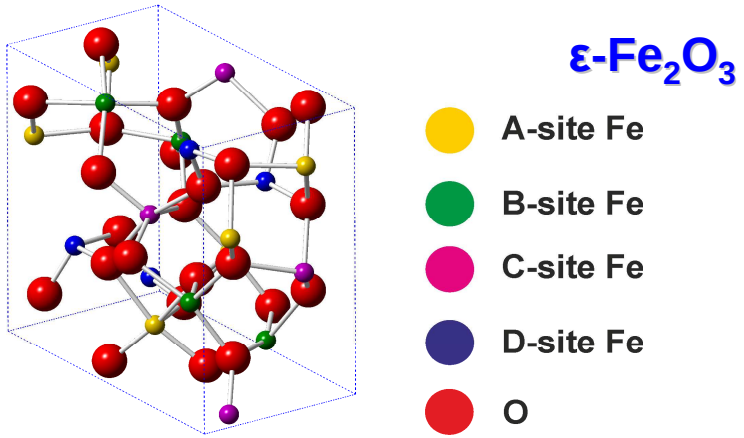
β-Fe_2O_3



γ-Fe_2O_3 (maghemite)

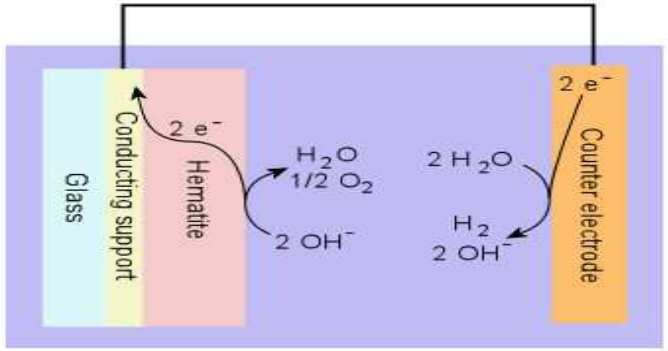


ε-Fe_2O_3

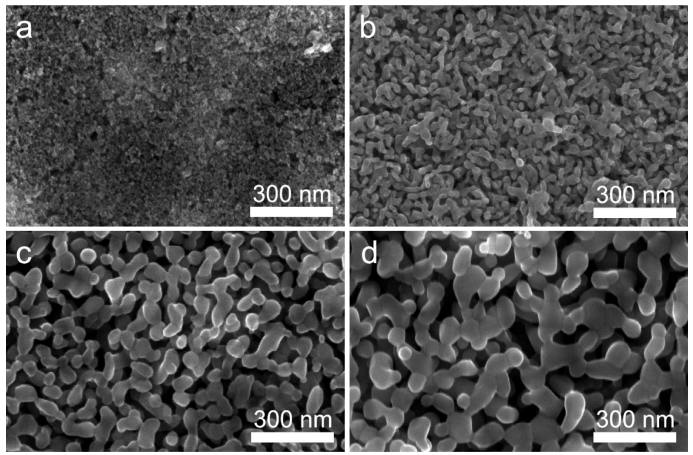


α-Fe_2O_3

Photocatalysis → solar cell applications → chemical storage of solar energy → water splitting

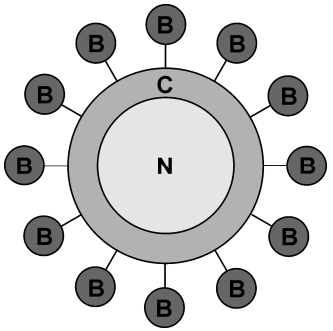


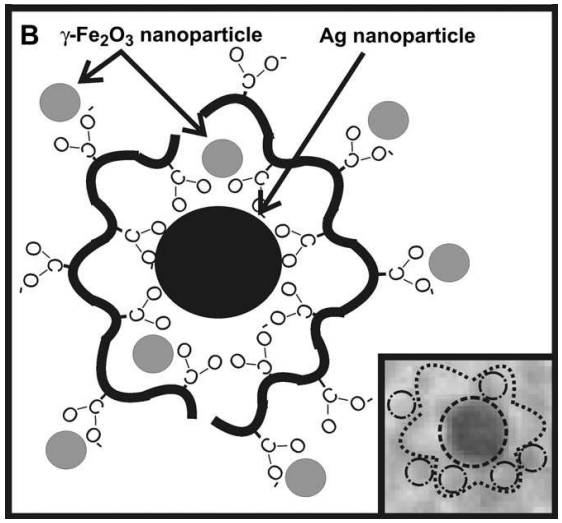
Grätzel Cell - Dye Sensitised Solar Cell (DSSC)

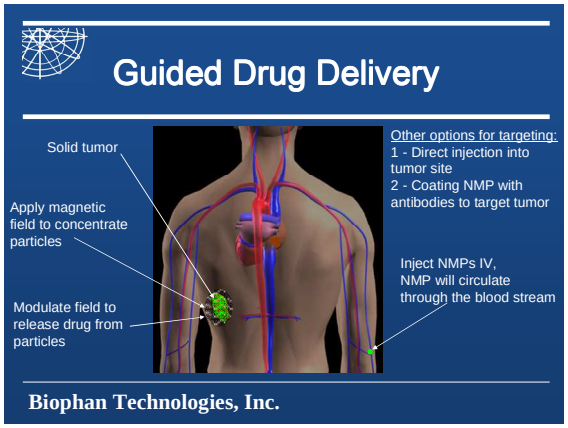


γ-Fe_2O_3/Fe_3O_4

Medicine

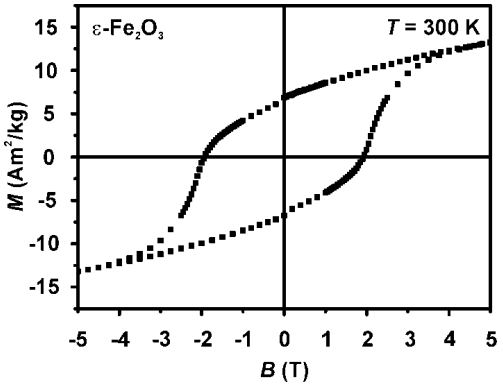


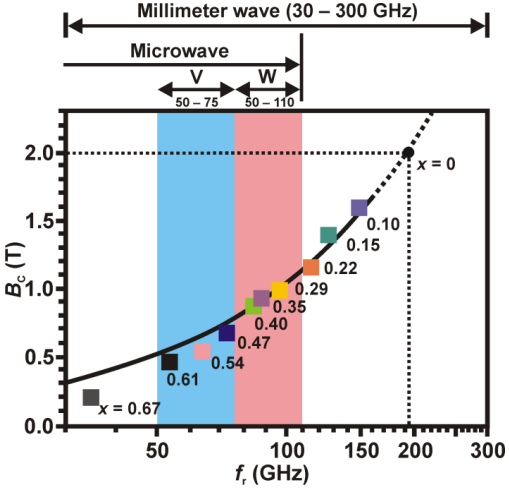




ε-Fe_2O_3

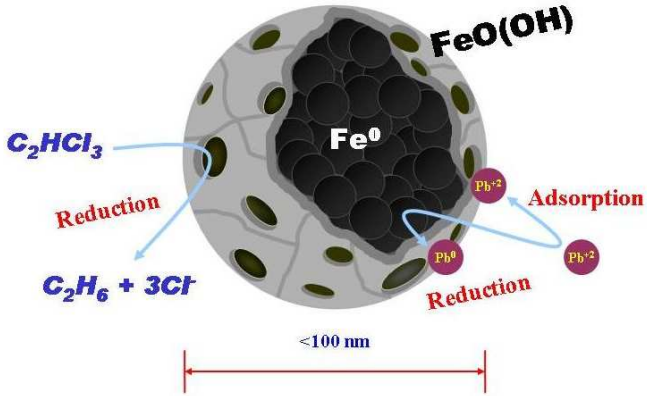
Technical applications



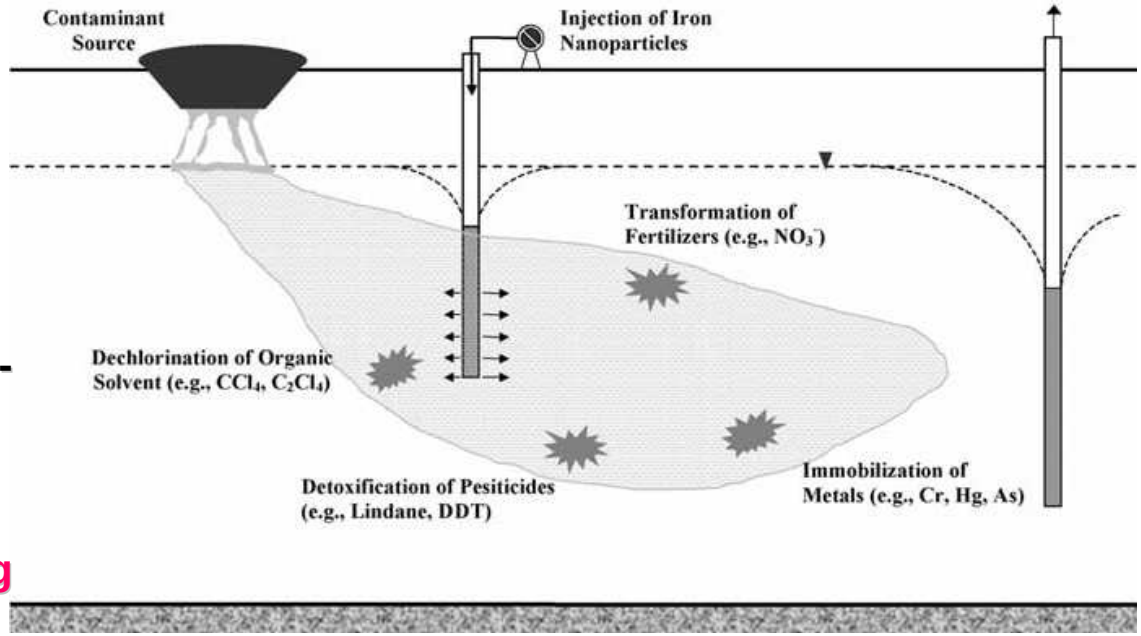


3. Zero-valent iron nanoparticles and their applications

Why nanoscale zero-valent iron nanoparticles (nZVI)?



- **Unusual properties compared to bulk iron** (e.g., extremely small size (down to 3-30 nm), large surface area, low standard reduction potential, high reactivity);
- **High potential for application in environmental in-situ techniques**.



Methods of synthesis of nZVI

1). Sonochemical;
2). Electrochemical;
3). Gas phase reduction;
4). Liquid phase reduction (borohydride reduction);
5). Ball-milling;
6). Cryogenic milling;
7). Solid-state reduction of Fe-bearing precursors at high temperatures.

→ Non-isothermal and isothermal heat treatment of suitable precursor under hydrogen

↓

Precursors: ferrihydrite ($Fe_5HO_8 \cdot 4H_2O$), goethite (FeOOH), maghemite (γ-Fe_2O_3), magnetite (Fe_3O_4), hematite (α-Fe_2O_3)

3. Zero-valent iron nanoparticles and their applications

Laboratory and pilot applications of nZVI

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