Environmental Implications of Copper Nanohybrids in Natural Waters

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Spot the Similarity!


NATURAL MINERAL FORMULA
babo
BOTANICALS
CLEAR ZINC
SUNSCREEN
SPF
30
ROAD SPECTRUM UVA/UVB PROTECTIO
FACE & BODY
FOR SENSITIVE SKIN
PURE. NATURAL. SOLUTIONS.
FOR BABIES AND KIDS OF ALL AGES
3 fl. oz. (89ml)


Sea
Hawk
Yacht Finishes
PREMIUM QUALITY
Mission Bay CSF
Copper-Free Antifouling Coating
ACTIVE INGREDIENT: Zinc Omadine 4.02%
OTHER INGREDIENTS: 95.98%
TOTAL 100.00%
4505 BLACK
KEEP OUT OF REACH OF CHILDREN
DANGER
SEE BACK PANEL FOR ADDITIONAL PRECAUTIONARY STATEMENTS


$1.99
Little Debbie
Mini Powdered
Donuts
Good & Plenty
Betty Crocker
Whipped
Fluffy White
Frosting
banana cream
JELL-O
Trident
PEANUT
m&m's
PEANUT
14.0 OZ 396.9g

PETER THOMAS ROTH
30
solbar
SHIELD
Zinc Oxide + Titanium Dioxide
SPF 40
super sensitive faceblock
spf30
dermalogica
PHYSICIANS FORMULA
Sun Shield
FOR FACES
SPF25


mixino
catlike


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I. What is Nanotechnology?

What is Nanotechnology?

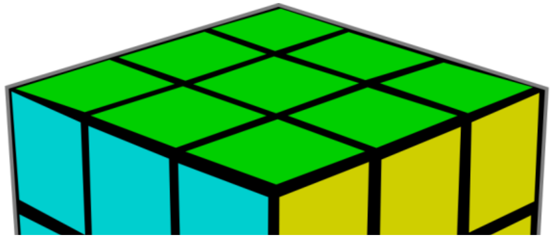
- Technology based on comprehending and manipulating matter at the nanoscale (1 – 100 nm) to create new and unique materials and products.

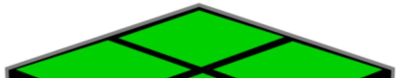
- Involves synthesis of nanomaterials and/or enabling products or processes with nanomaterials.

http://sethow.com/index.php/2015/10/27/complete-introdution-to-nanotechnology/

Scale of Nanotechnology?

Effect of Size





A gold slab melts around 1064 °C; 2.5 nm gold particles melt around 300 °C!

sides = 3
surface = $3^2 \times 6 = 54$
volume = $3^3 = 27$

surface/volume = 2

sides = 2
surface = $2^2 \times 6 = 24$
volume = $2^3 = 3$

surface/volume = 3

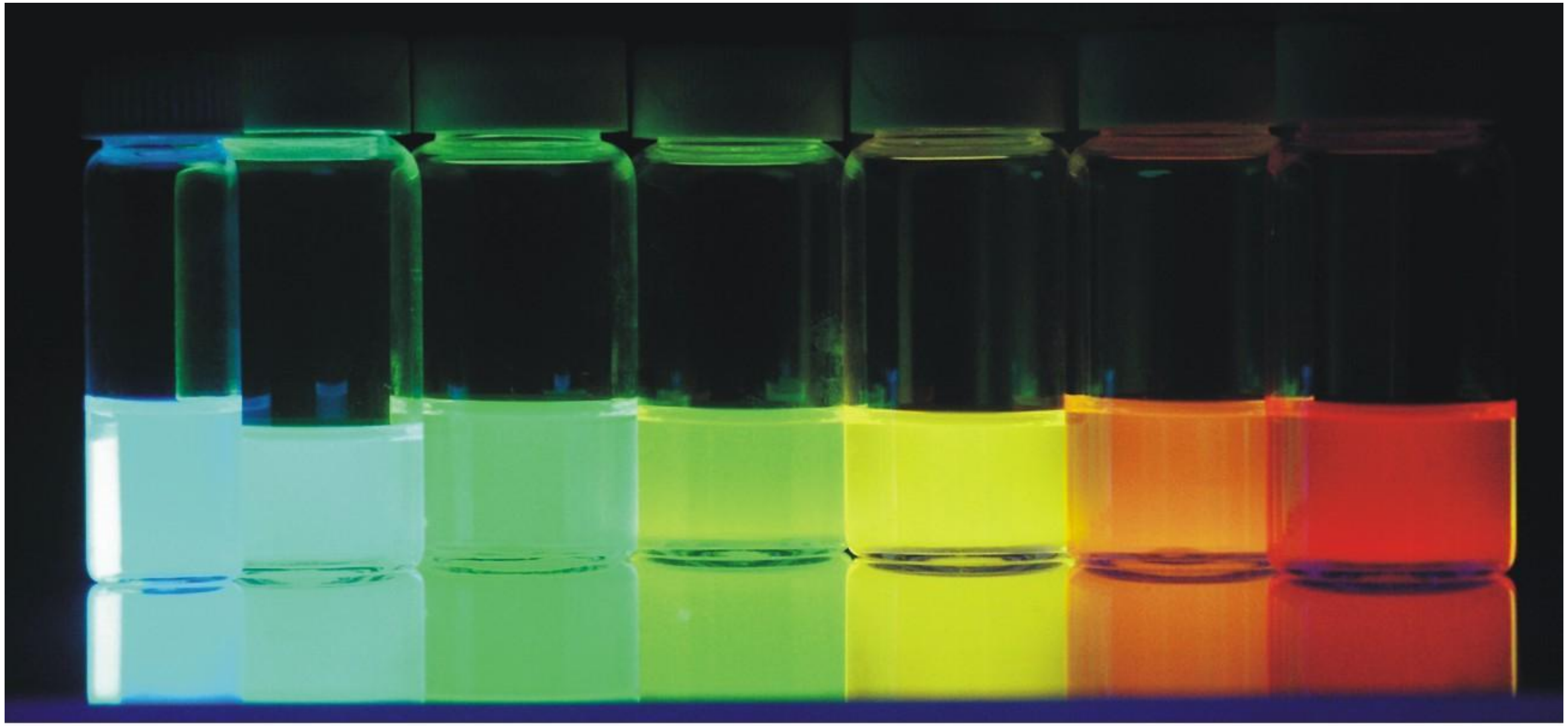
sides = 1
surface = $1^2 \times 6 = 6$
volume = $1^3 = 1$

surface/volume = 6

http://sustainable-nano.com/2014/09/23/nano-sensors-small-size-big-impact/

Effects of Nanoscale Size

Properties	Examples
Catalytic	Increased catalytic efficiency through higher surface-to-volume ratio
Electrical	Increased electrical conductivity in ceramic and magnetic composites; increased electric resistance in metals
Magnetic	Increased magnetic coercivity up to a critical grain size; superparamagnetic behavior
Mechanical	Improved hardness and toughness of metals and alloys; ductility and superplasticity of ceramic
Optical	Spectral shift of optical absorption and fluorescence properties; increased quantum efficiency of semiconductor crystals
Sterical	Increased selectivity; hollow spheres for specific drug transportation and controlled release
Biological	Increased permeability through biological barriers



2.3 → 5.5

Size (nanometers)

http://genesisnanotech.com/2016/01/

Nano TiO_2

http://www.motherearthnews.com/natural-health/nutrition/is-nanotechnology-safe-zmgz14onzsto
http://tinaounds2016.blogspot.com/

Nano Ag

http://nanoall.blogspot.com/2012/07/nanotechnology-in-food-and-beverage.html
http://www.ecouterre.com/silver-nanoparticles-in-clothing-could-harm-plant-life-says-new-study/

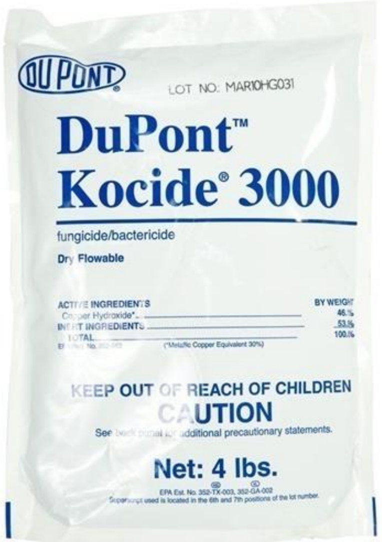
Graphene

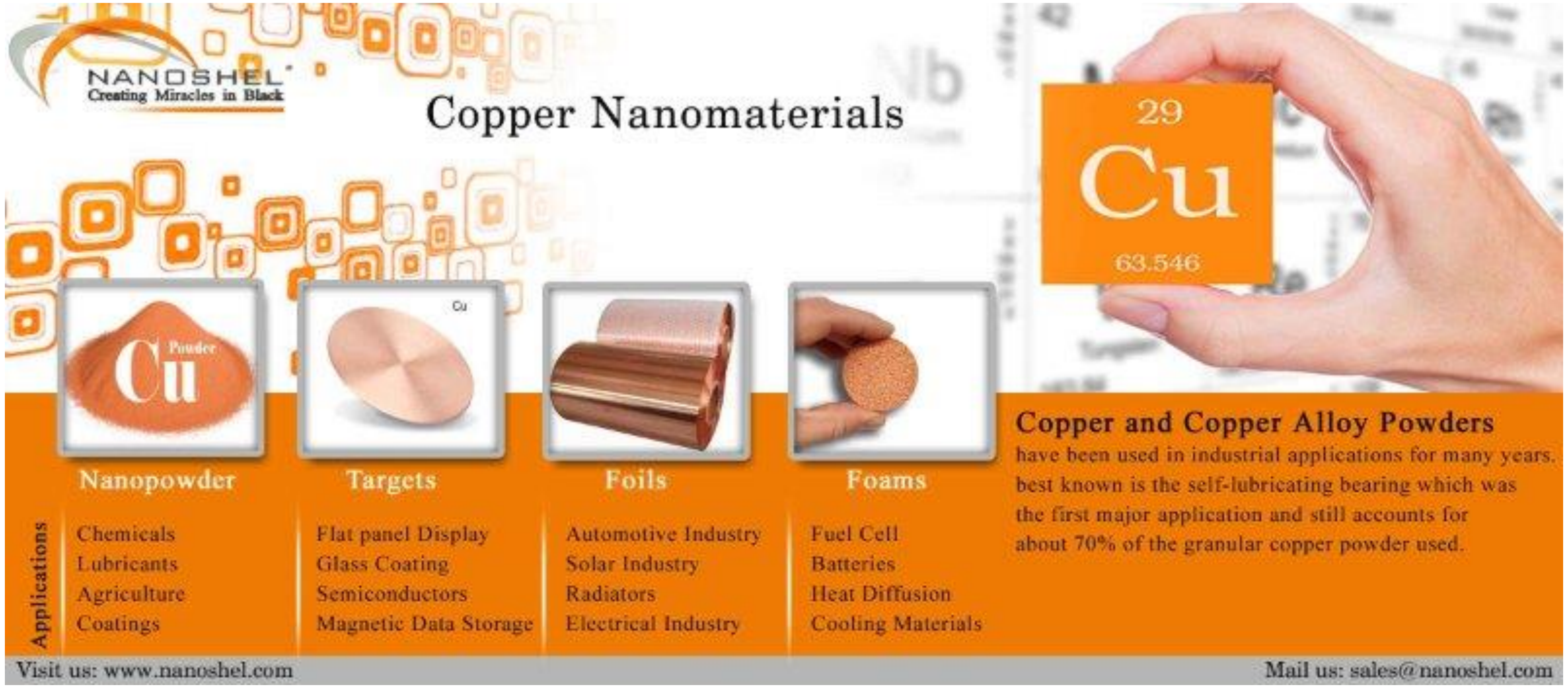
https://www.catlike.es/global/en/helmets/mountain-bike/mixino-mtb/
http://www.dailymail.co.uk/sciencetech/article-3607191/Bendable-smartphones-coming-Devices-screens-graphene-flexible-worn-like-BRACELET.html

Nano ZnO

http://www.bottompaintstore.com/mission-bay-csf-coppersolvent-free-bottom-paint-p-9482.html
https://gimmethegoodstuff.org/safe-product-guides/sunscreen/

Some Uses of “Nanoscale” CuX





II. Environmental Implications

Environmental Implications of Nanotechnology

Release

- Pulse/continuous
- Mass

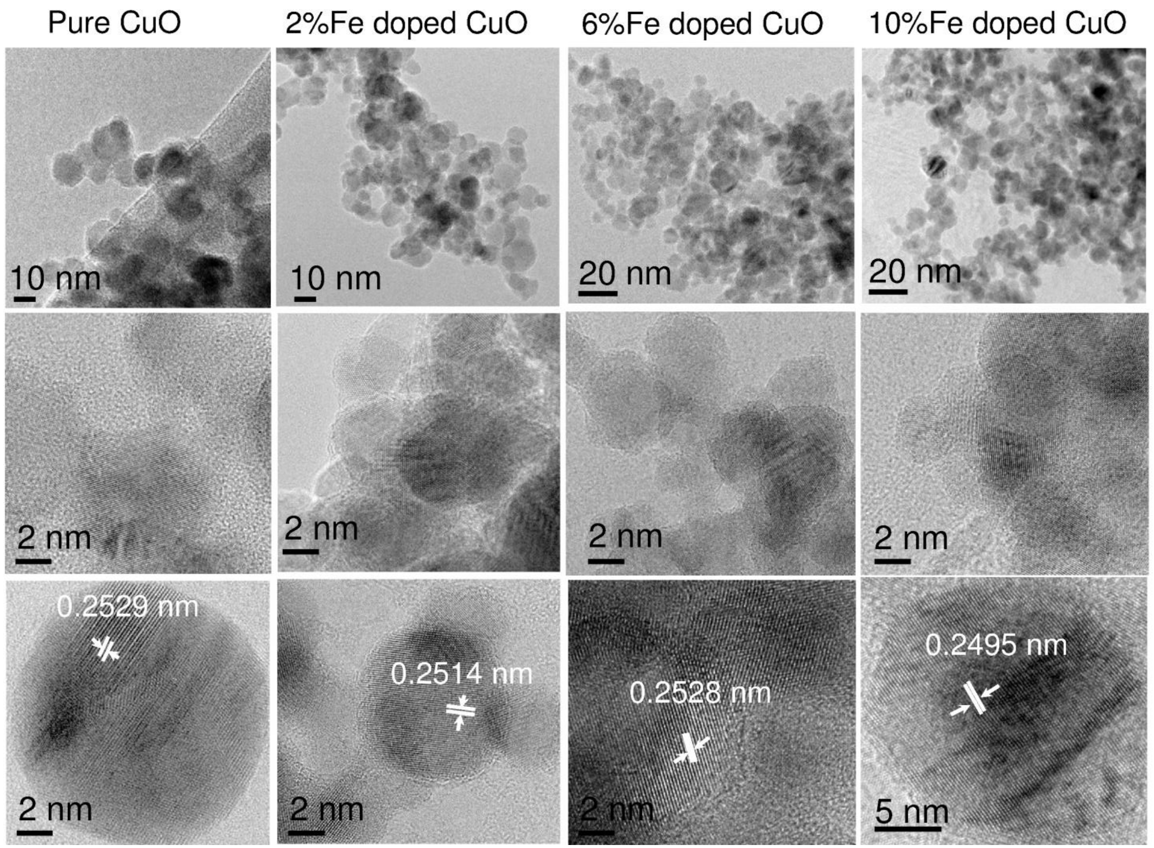
Fate

- Dissolution
- Aggregation
- Sedimentation
- Transformations
- Interactions

Effects

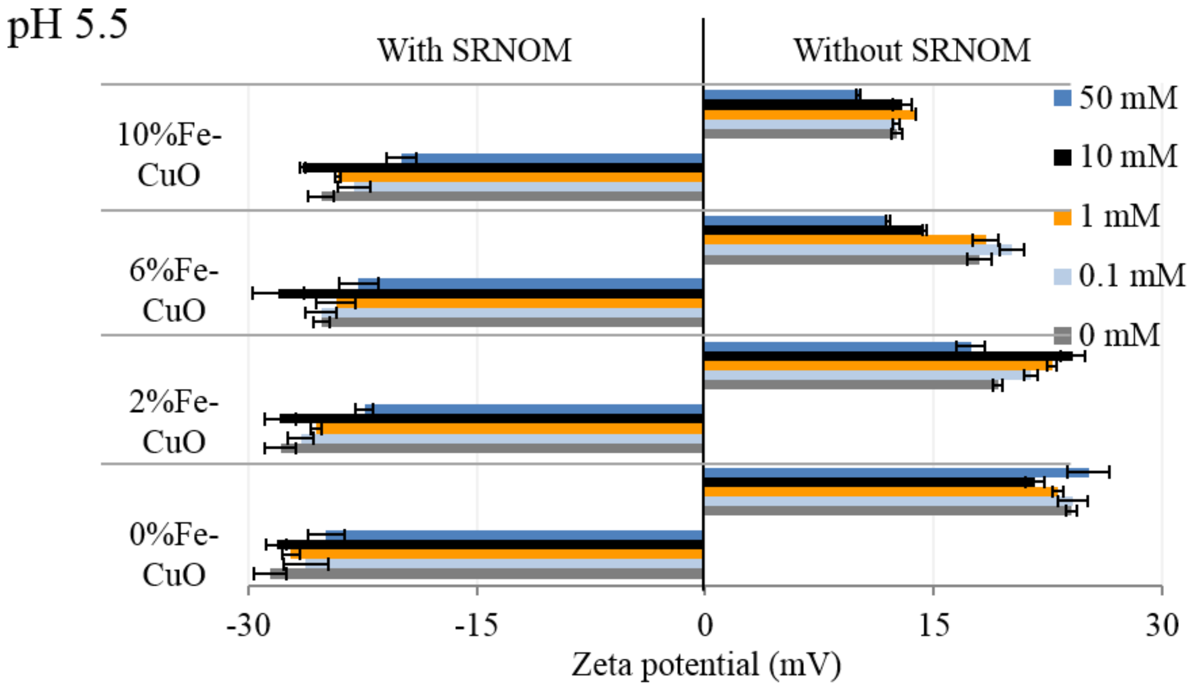
- Bioaccumulation
- Sub-lethal effects
- Lethal effects

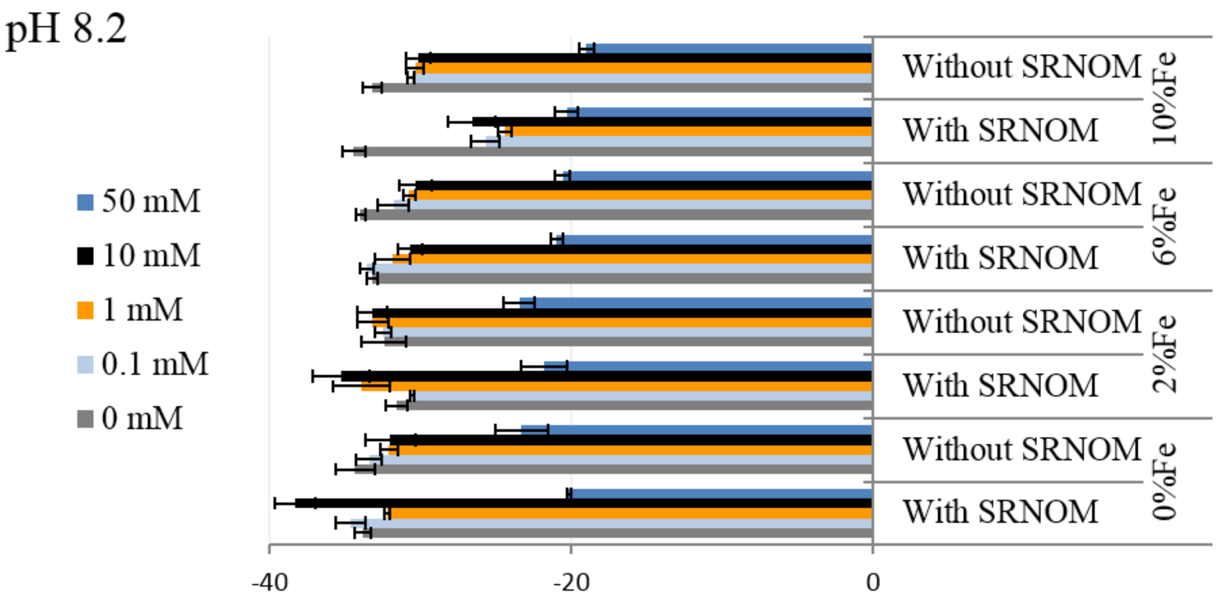
Fe-doped CuO Nanoparticles



Characteristic	0%Fe-CuO	2%Fe-CuO	6%Fe-CuO	10%Fe-CuO
Crystallite size, d_{XRD} (nm)	8.9 (±1)	92(±1)	11.6(±1)	11.4(±1)
Particle size, d_{BET} (nm)	11.8(±2)	12.3(±2)	10.3(±2)	10.7(±2)
Hydrodynamic size (nm)[a]	162.9 ± 3.5	145.1 ± 6.5	165.2 ± 11.9	157.7 ± 11.4
Zeta potential (mV) [a, b]	-33.4 ± 0.9	-32.5 ± 0.6	-31.8 ± 1.0	-30.6 ± 0.3
Isoelectric point	~ pH 9.8	~ pH 9.5	~ pH 9.2	~ pH 9.0
Specific surface area (m^2/g)	80.9(±5)	77.6(±5)	92.9(±5)	90.4(±5)

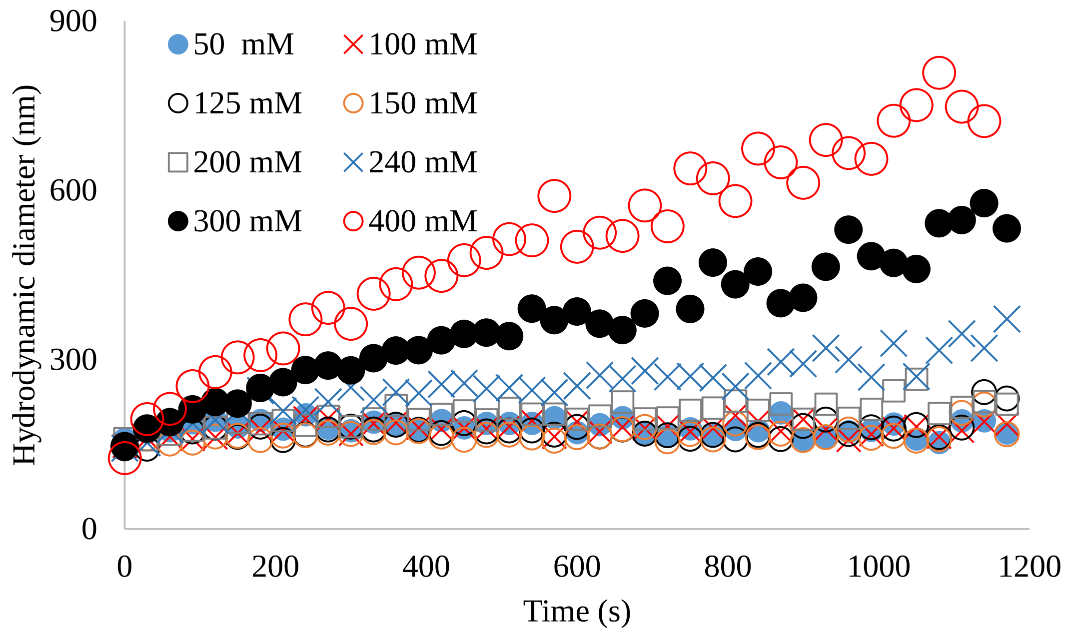
Surface Charge of Fe-doped *n*CuO

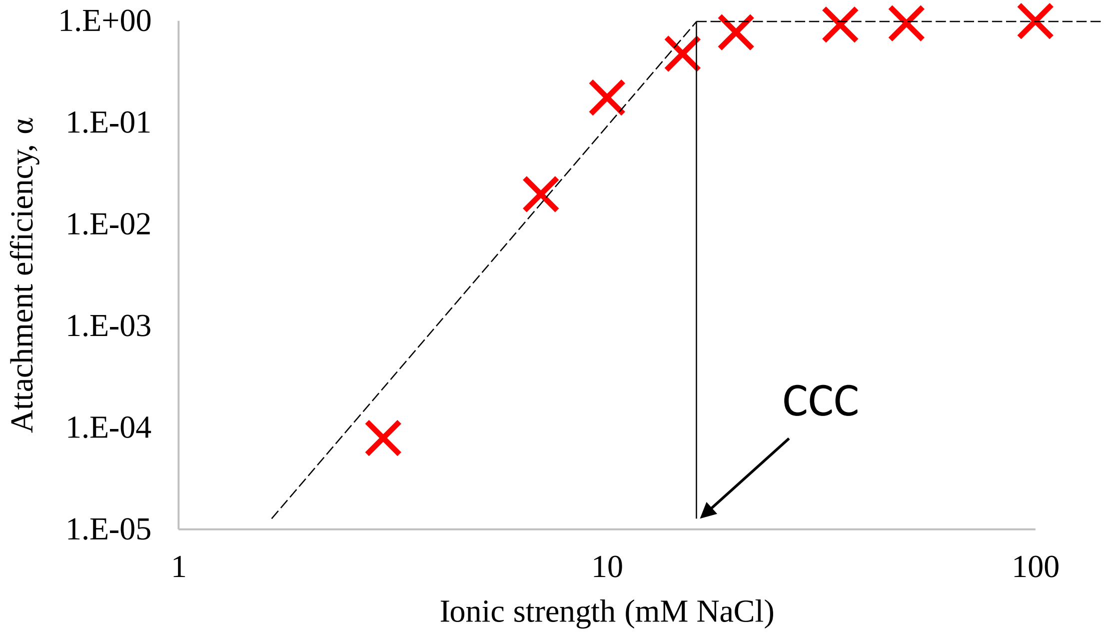




Instrument: Malvern Zetasizer ZS90

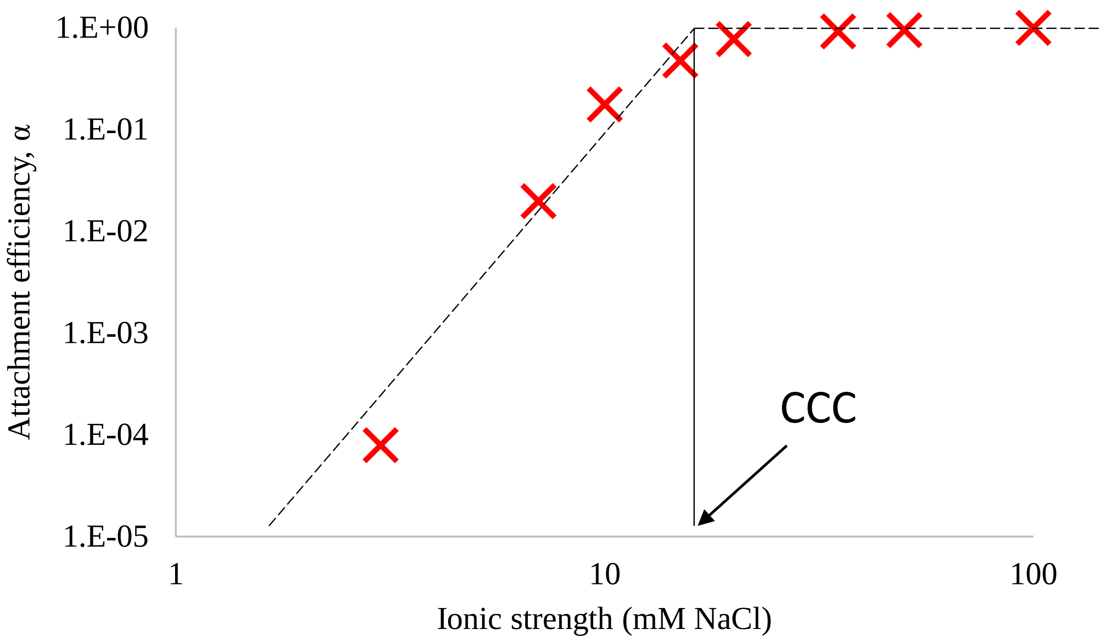
Aggregation Kinetics

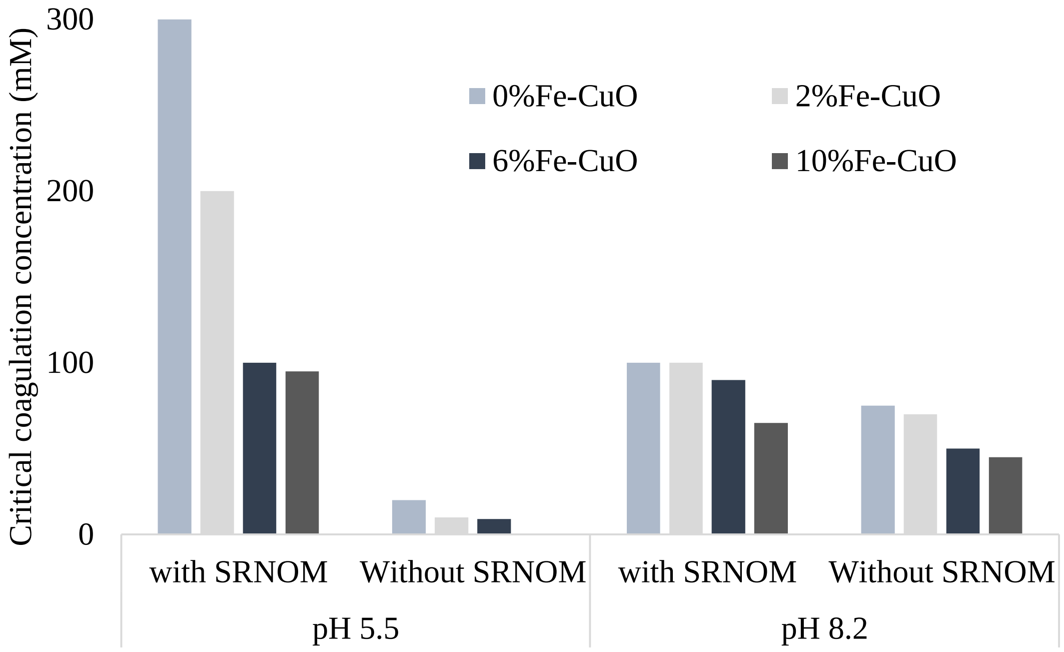




Instrument: Malvern Zetasizer ZS90

Stability of Fe-doped *n*CuO

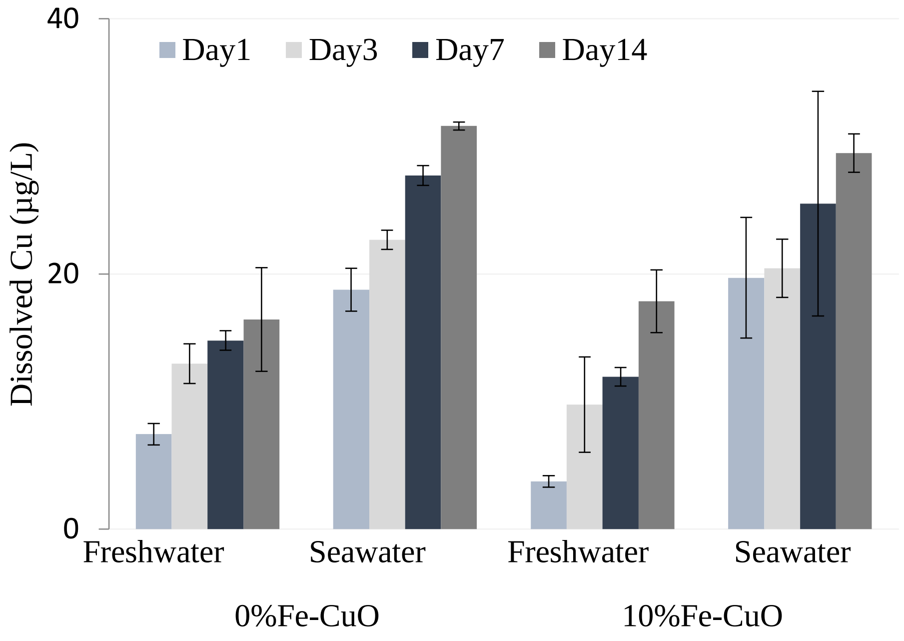


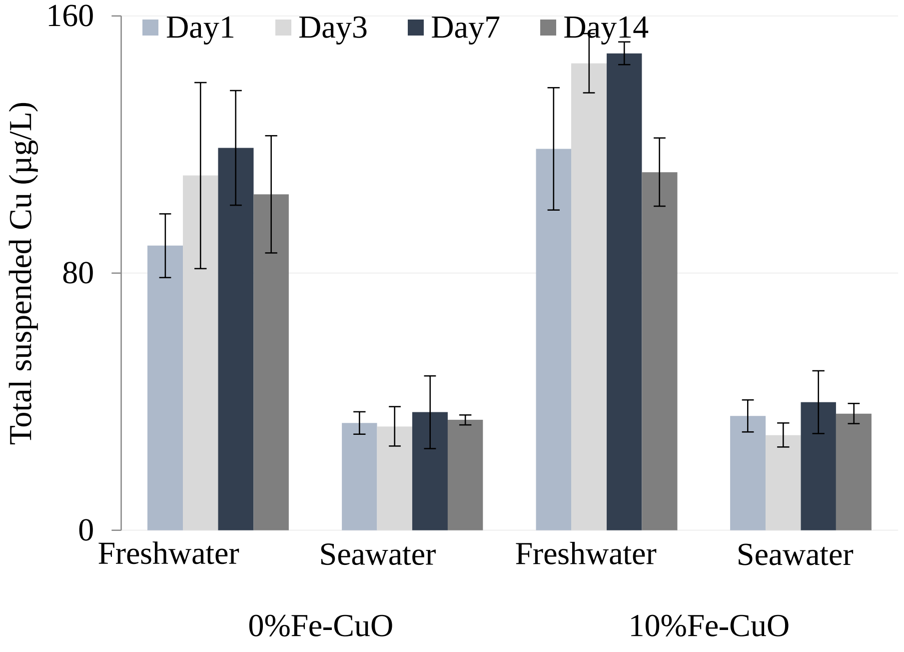


Instrument: Malvern Zetasizer ZS90

Dissolution and settling of Fe-doped *n*CuO

Initial concentration = 500 µg/L

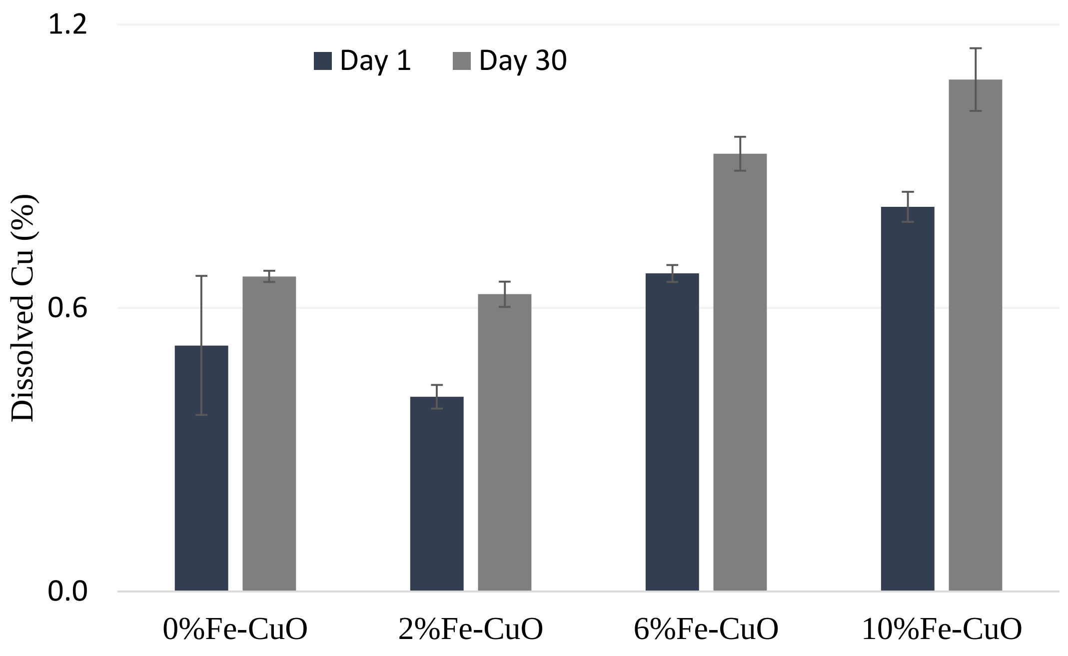


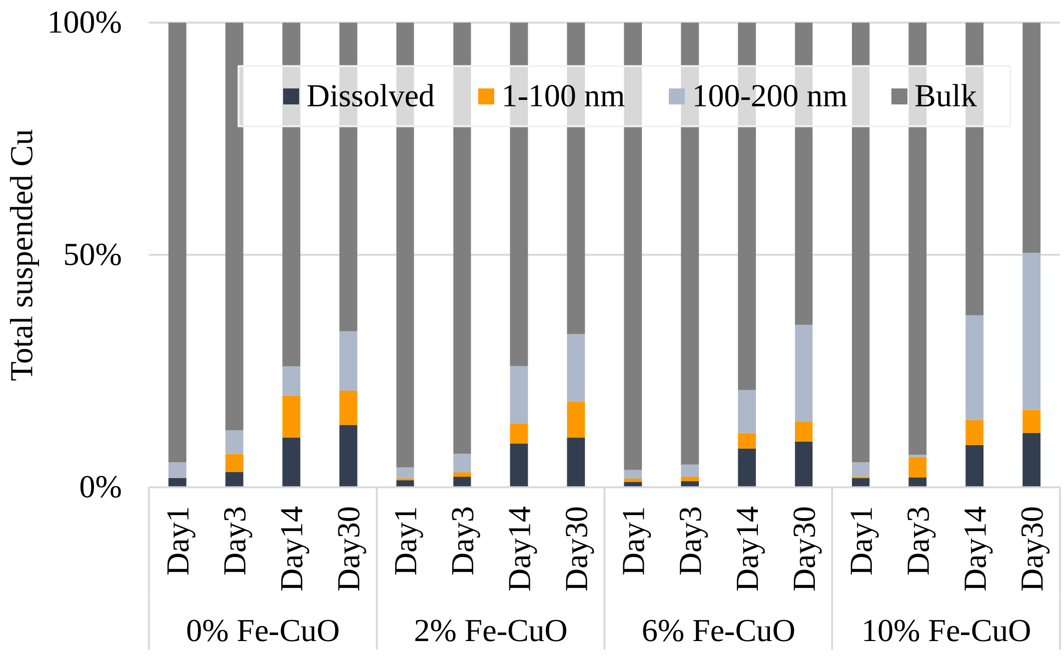


Instrument: Agilent 7900 ICP-MS

Dissolution and Settling of Fe-doped *n*CuO

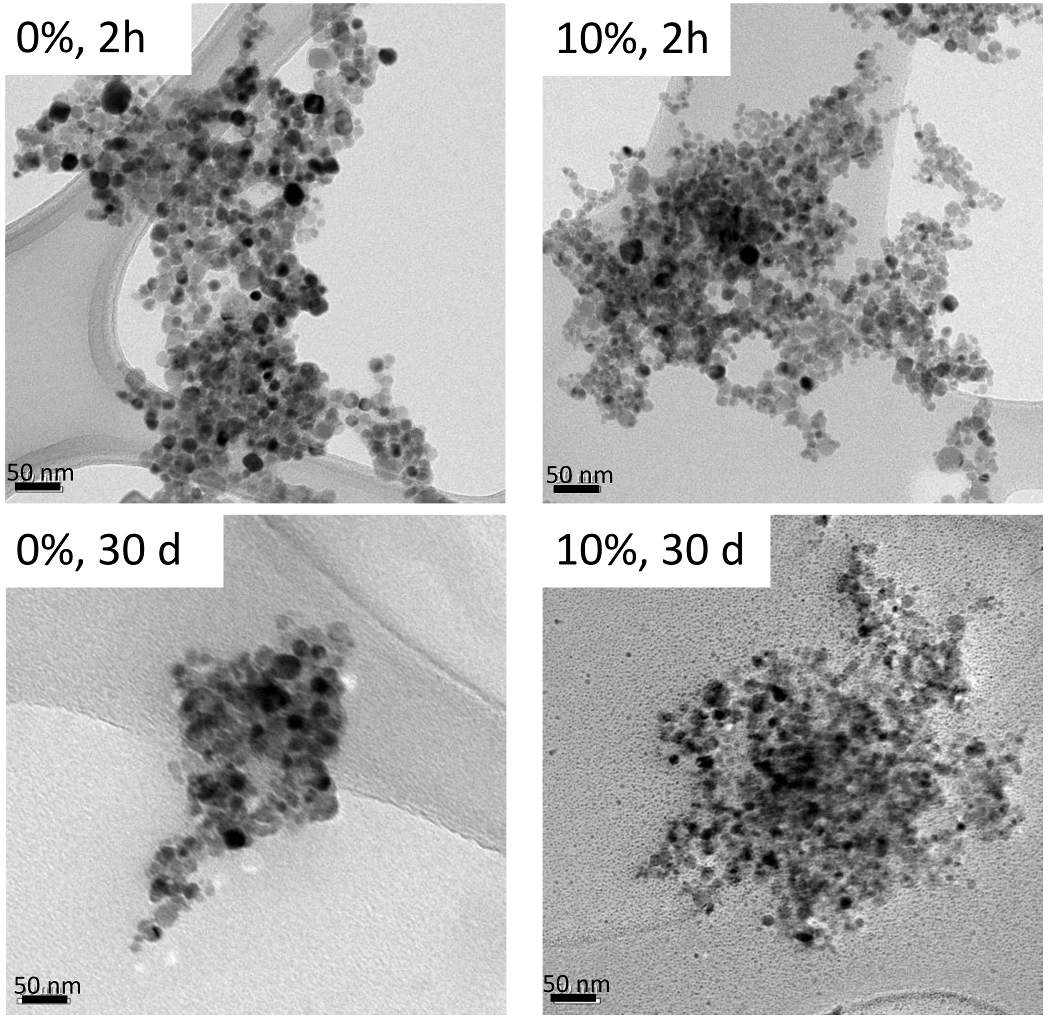
Initial concentration = 5000 µg/L

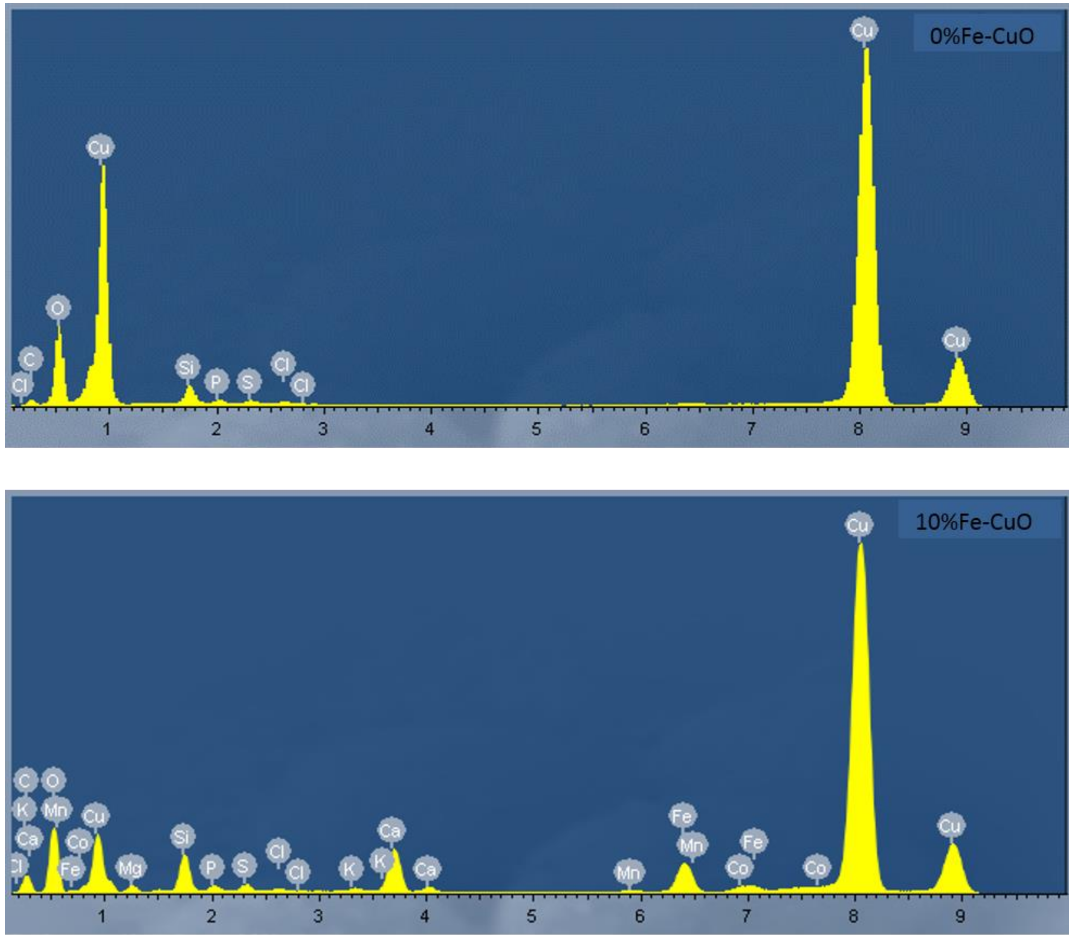




Instrument: Agilent 7900 ICP-MS

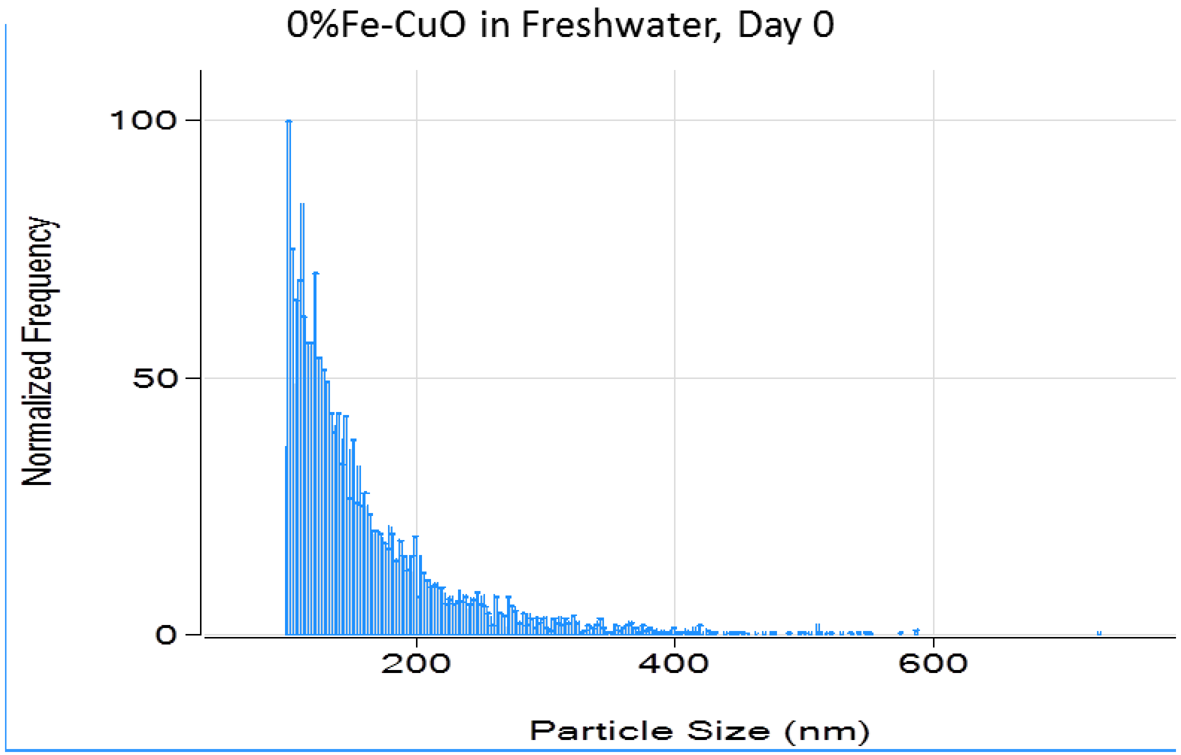
"Bulk Cu"?

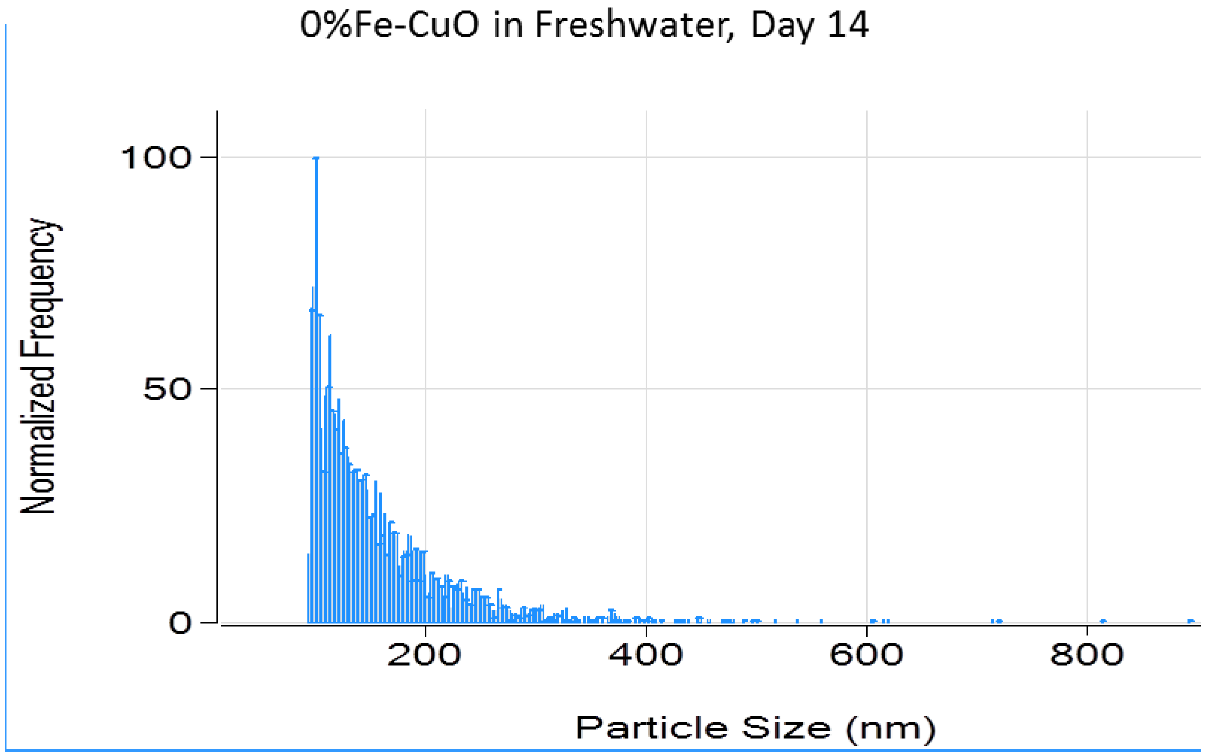




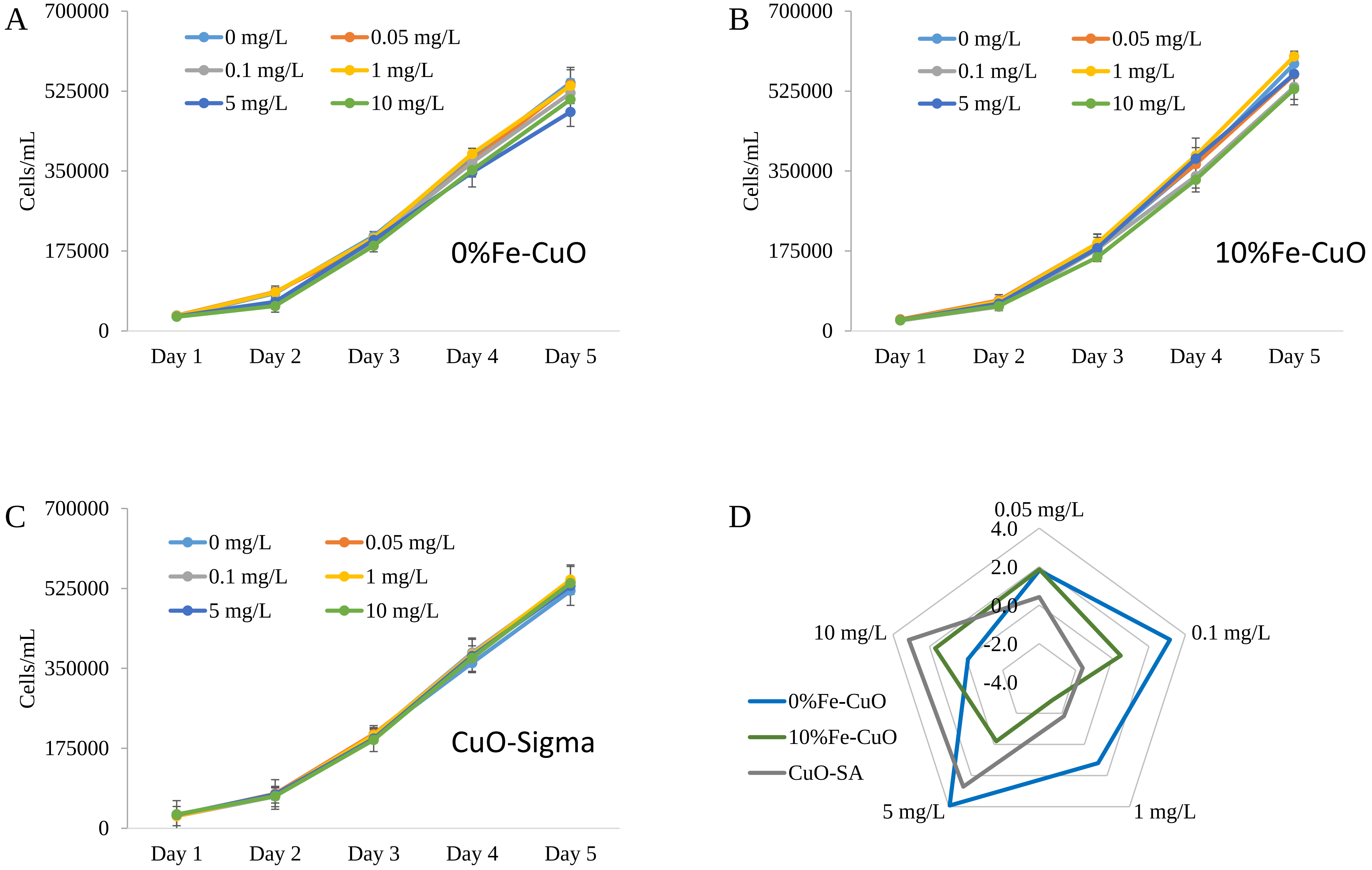
Instrument: FEI Tecnai G2 Sphera 200 kV TEM

Particle Size Distribution

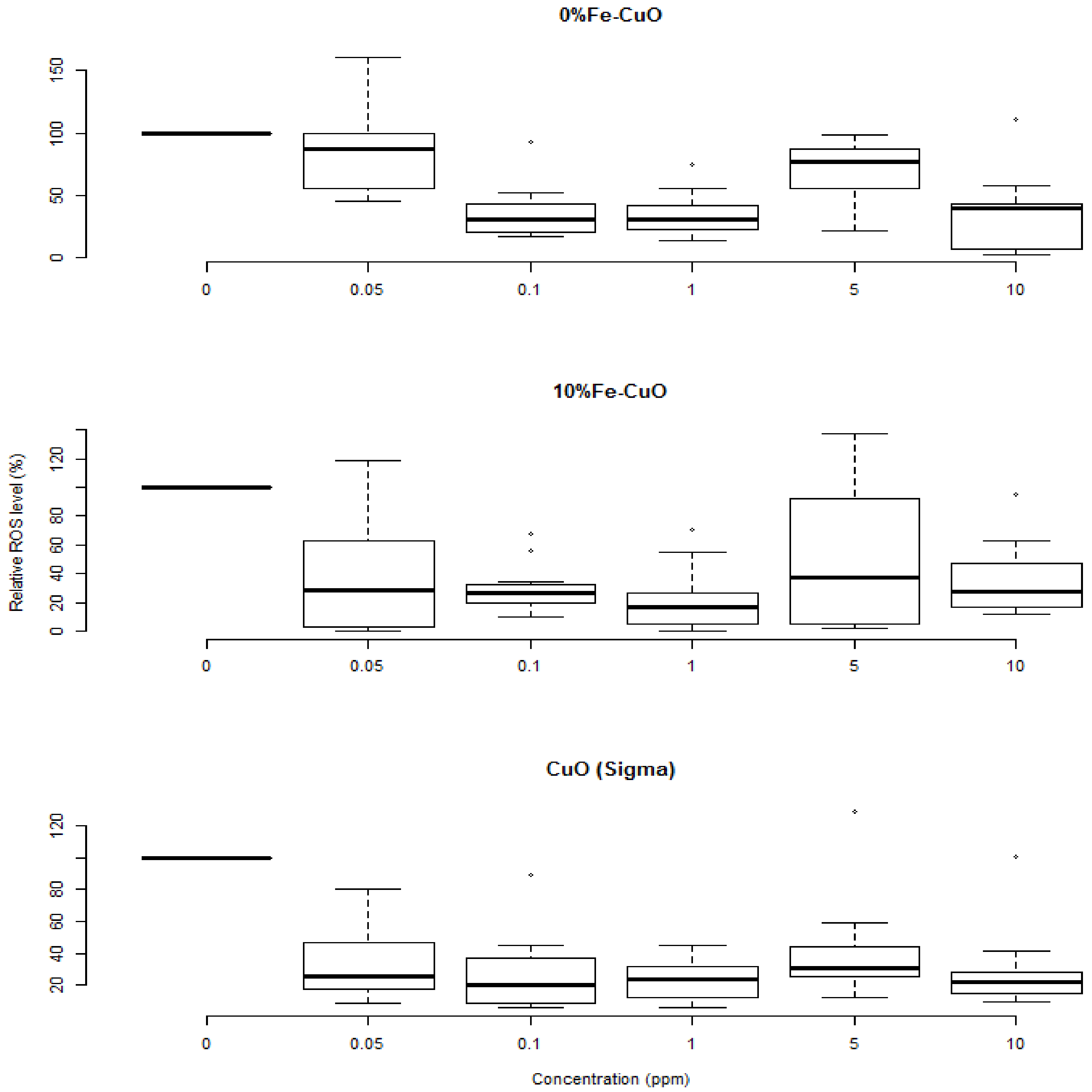




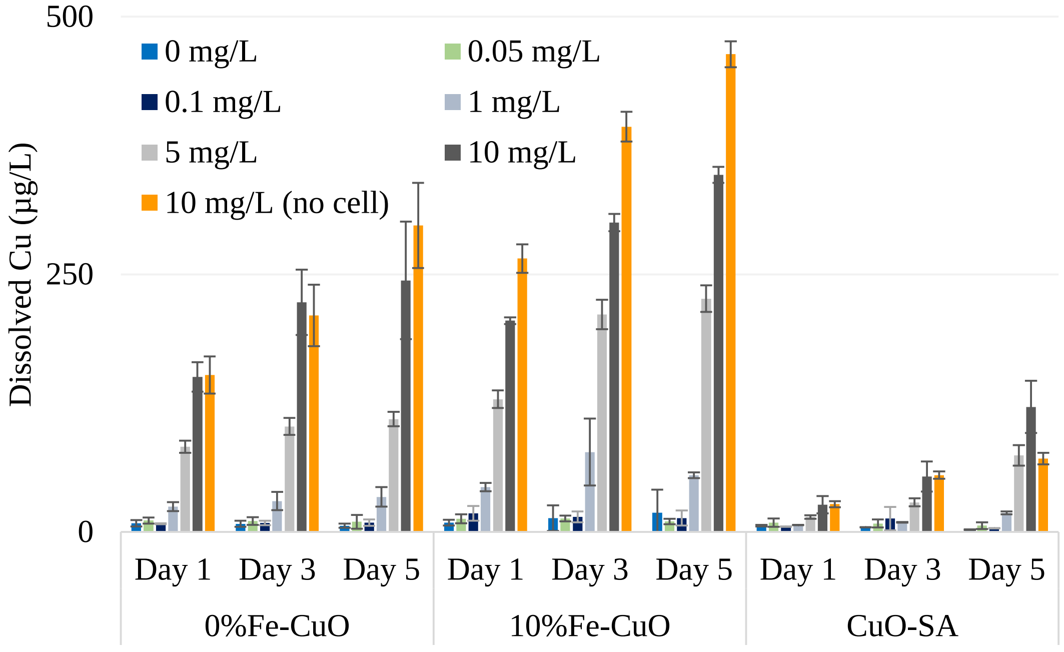
Instrument: Agilent 7900 ICP-MS

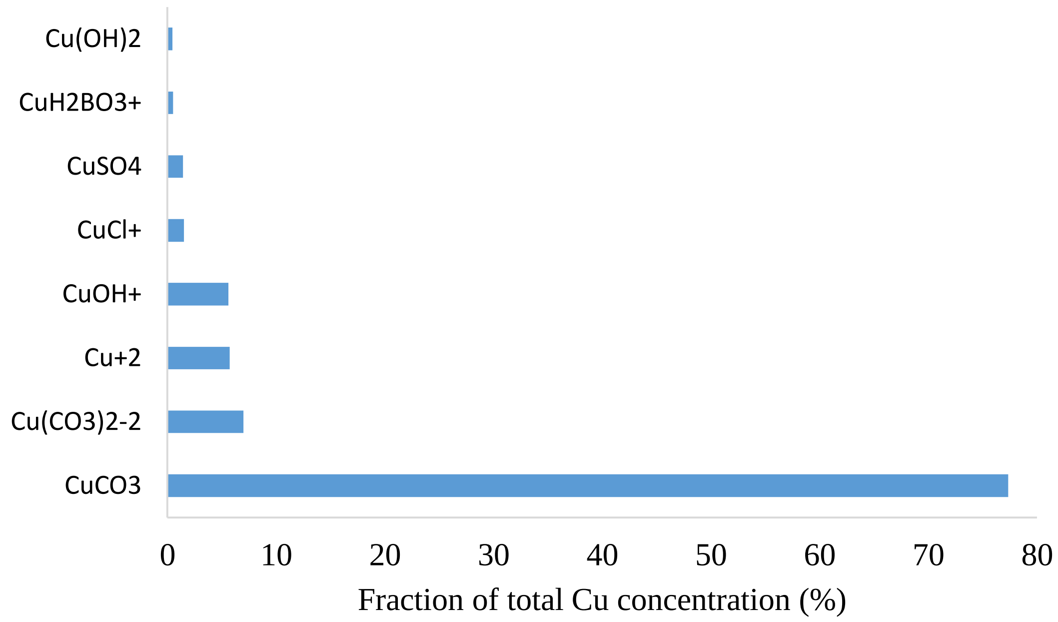


Instrument: Synergy H1 Microplate Reader (Biotek Instruments)


0%Fe-CuO
10%Fe-CuO
CuO (Sigma)
Relative ROS level (%)
Concentration (ppm)
0
0.05
0.1
1
5
10

Dissolved Cu and Cu Species in Seawater





Instrument: Agilent 7900 ICP-MS

Conclusion

- Doping of CuO nanoparticles with Fe affected the surface charge and colloidal stability of the nanoparticles
- Fe-doping increased release of Cu from CuO nanoparticles into both freshwater and seawater.
- The effect of CuO (pure and Fe-doped) on the growth of marine phytoplankton was enhanced or inhibited by less than 4%

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