Electron Storage Capacities (ESC) of Biochar and Other Black Carbon Materials

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BIOCHAR 2018
Wilmington, August 22, 2018

Biochar as a Sorbent

Redox Processes?

Electron Storage Capacity (ESC)

Metal Ions

- Hg, Pb, Cd, Cu, etc.

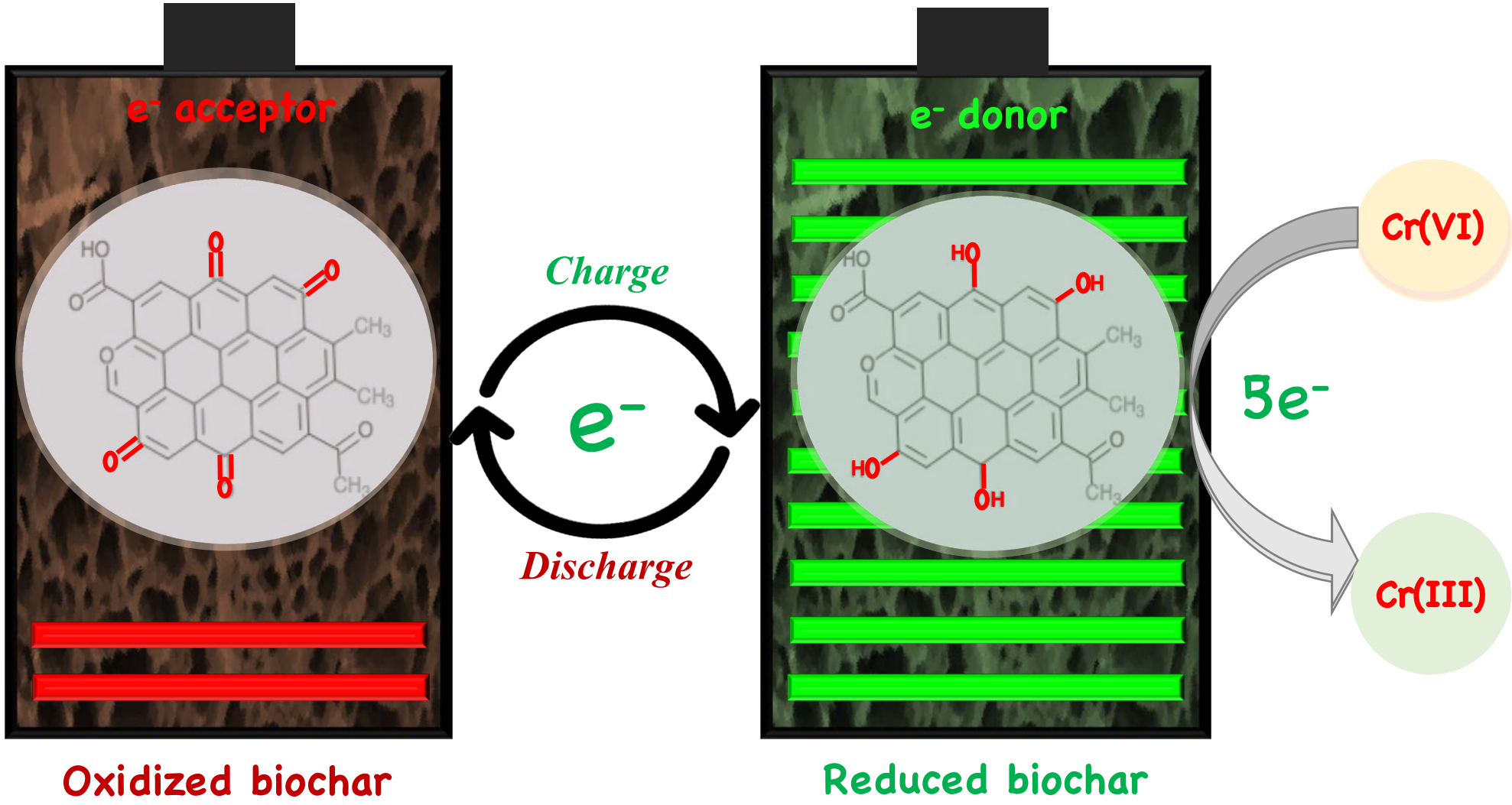
Cation Exchange Capacity

Organic Compounds

- Hydrophobic organic compounds e.g., herbicides, halocarbons, pharmaceuticals, etc.

BET Surface Area

Biochar as a Rechargeable Battery



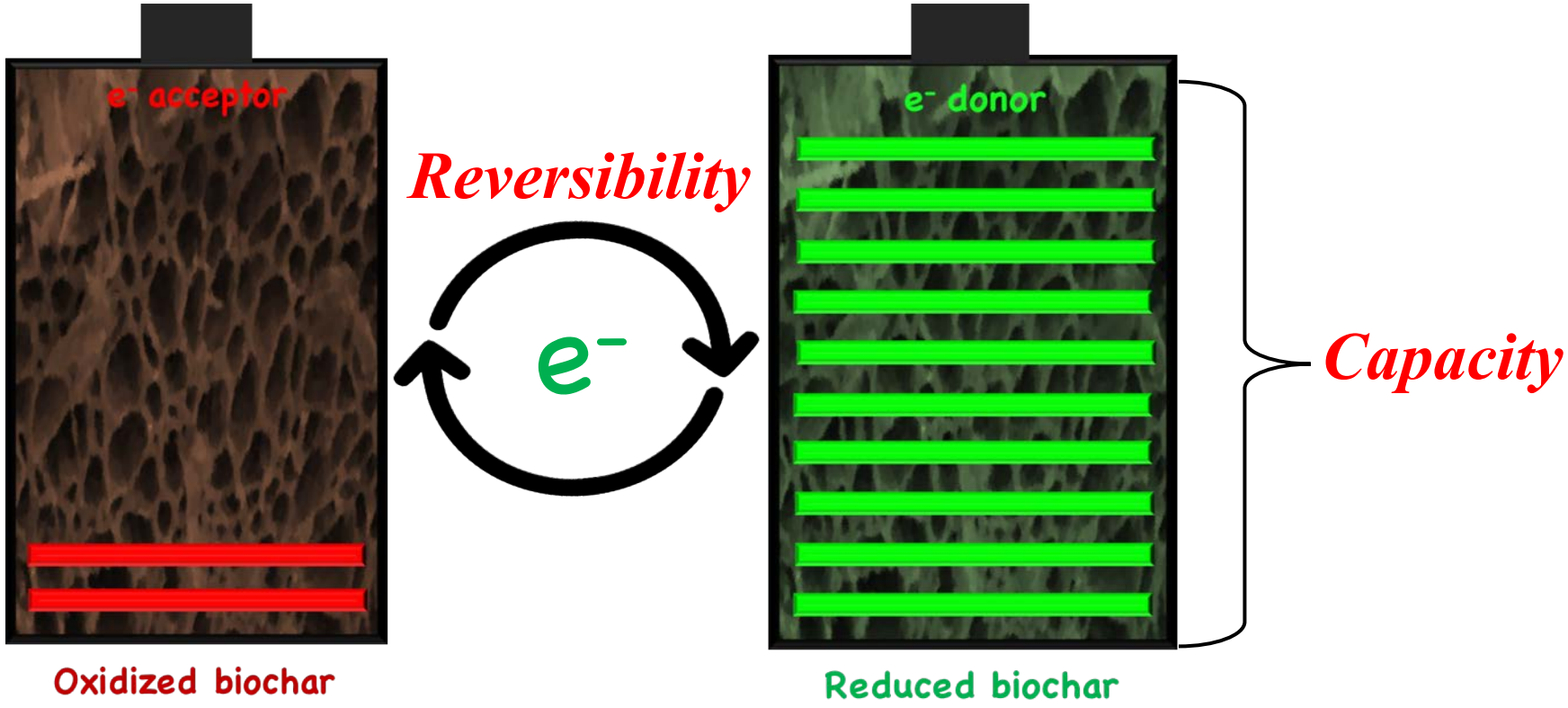
Electron Storage Capacity of Biochar

- The ESC of biochar is a new property, first demonstrated by Michael Sander of ETH Zurich in 2014.[1]
- Chiu's group showed that Soil Reef biochar (SRB) can serve as a reversible electron donor and acceptor for *G. metallireducens* to reduce nitrate and oxidize acetate, respectively. The ESC of SRB accessible to *G. metallireducens* was ~0.86 mmol/g (2016).[2]
- In field pilot-scale bioretention cells, Imhoff's group showed SRB significantly and consistently enhanced nitrate removal from stormwater (2018).[3]

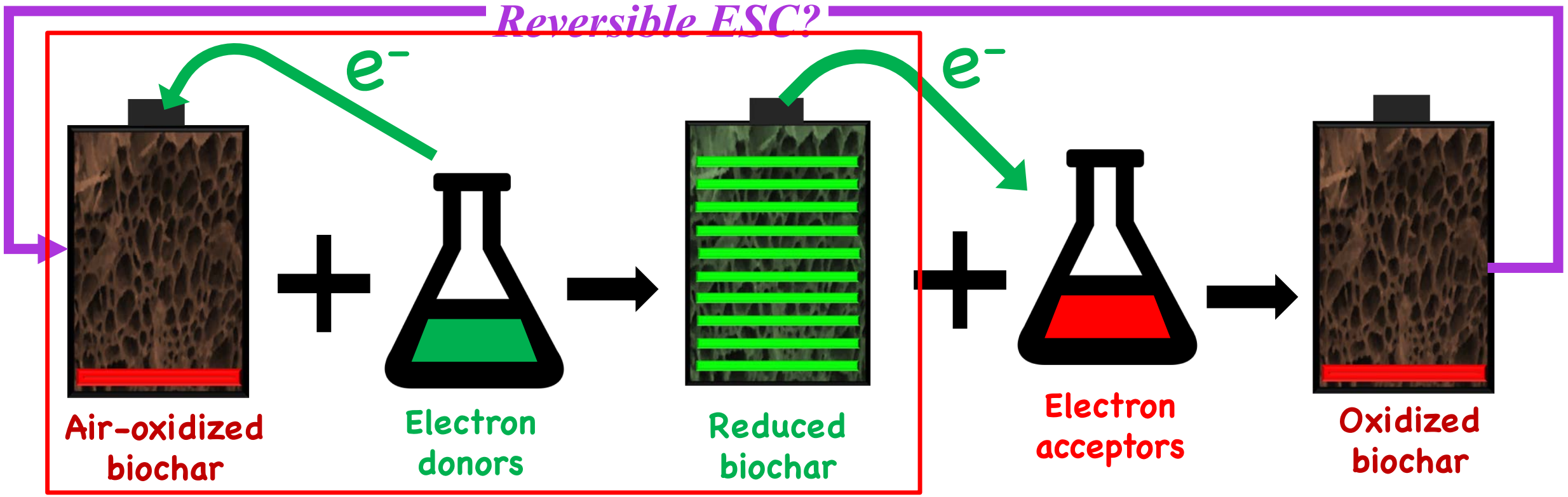
[1] Klüepfel, L.; Keiluweit, M.; Kleber, M.; Sander, M., Redox properties of plant biomass-derived black carbon (Biochar). *Environ Sci Technol* 2014, 48(10), 5601-5611
[2] Saquing, J. M.; Yu, Y. H.; Chiu, P. C., Wood-derived black carbon (biochar) as a microbial electron donor and acceptor. *Environ Sci Tech Lett* 2016, 3(2), 62-66.
[3] Tian, J.; Jin, J.; Chiu, P. C.; Cha, D. K.; Guo, M., Imhoff, P. T., A pilot-scale, bi-layer bioretention system with biochar and zero-valent iron for enhanced nitrate removal from stormwater. Water Res, In review.

Objectives

To develop new methods to assess ESC and redox reversibility of biochar



Experimental Design



Ti(III) citrate

or

Dithionite

Ti(III)→Ti(IV)+e⁻

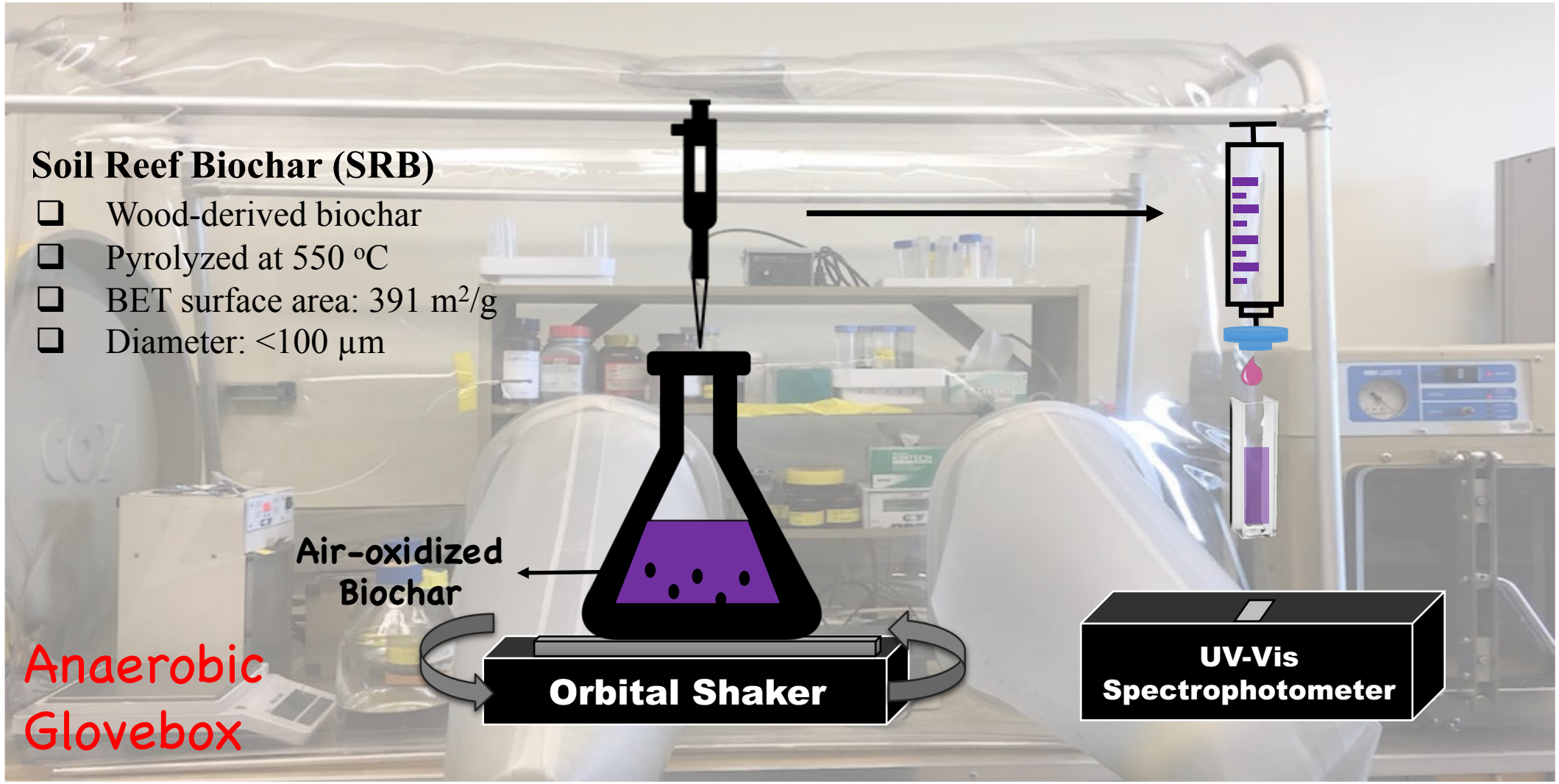
- ❑ Colored, measurable by UV-Vis
- ❑ Single electron transfer
- ❑ Negatively charged, limited sorption
- ❑ Stable in the glovebox

Dissolved O_2(DO)

or

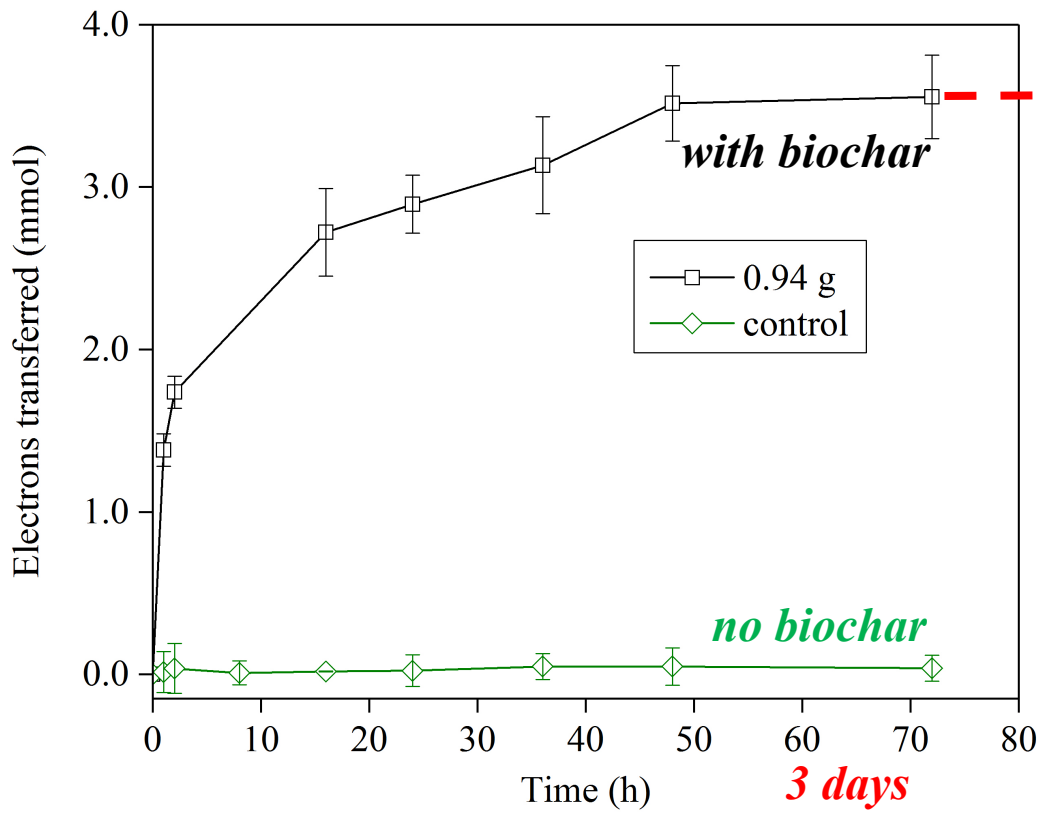
Fe(II) cyanide

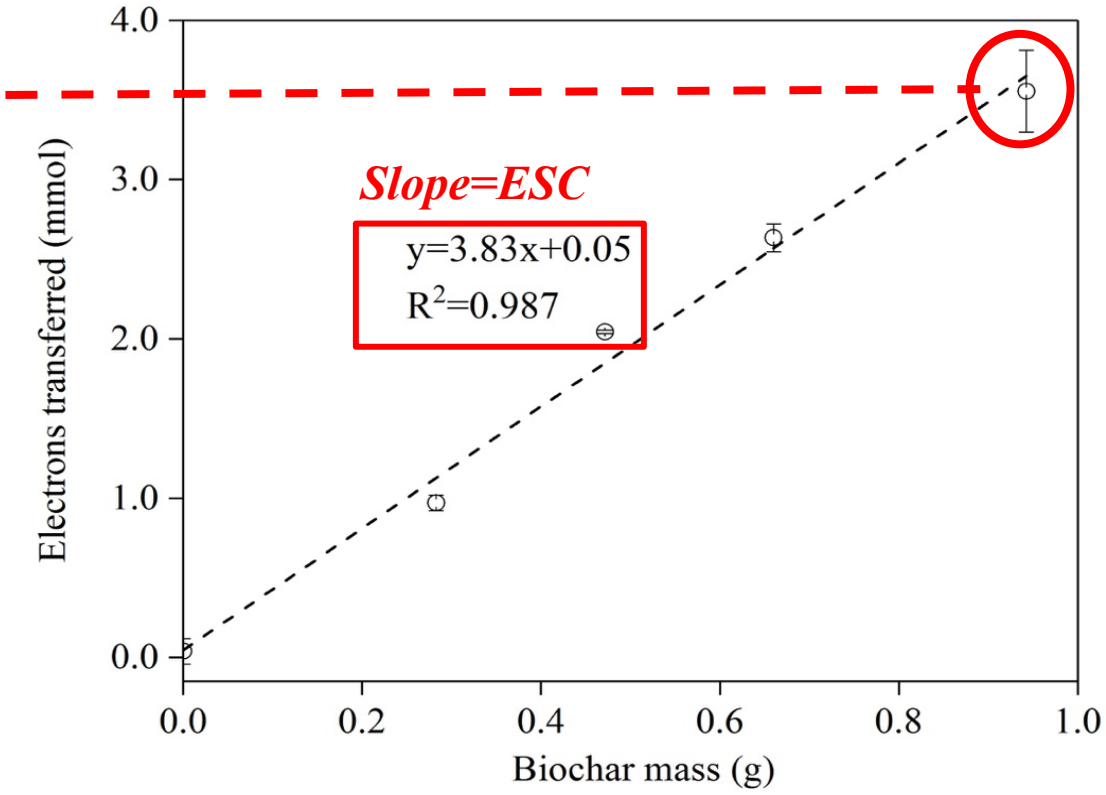
Experimental Setup



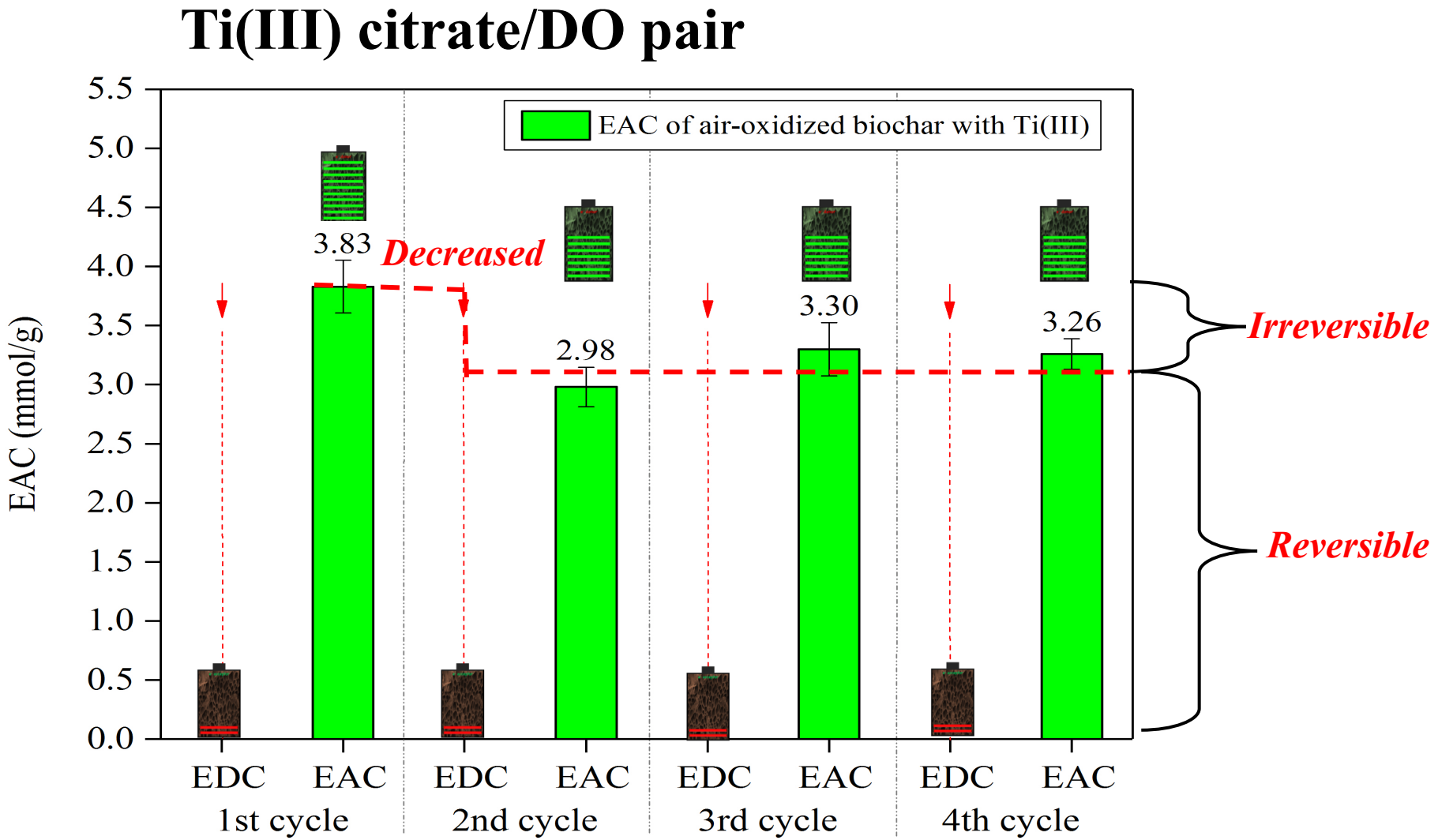
EAC Measurement with Ti(III) Citrate

Reduction of air-oxidized biochar by Ti(III) citrate





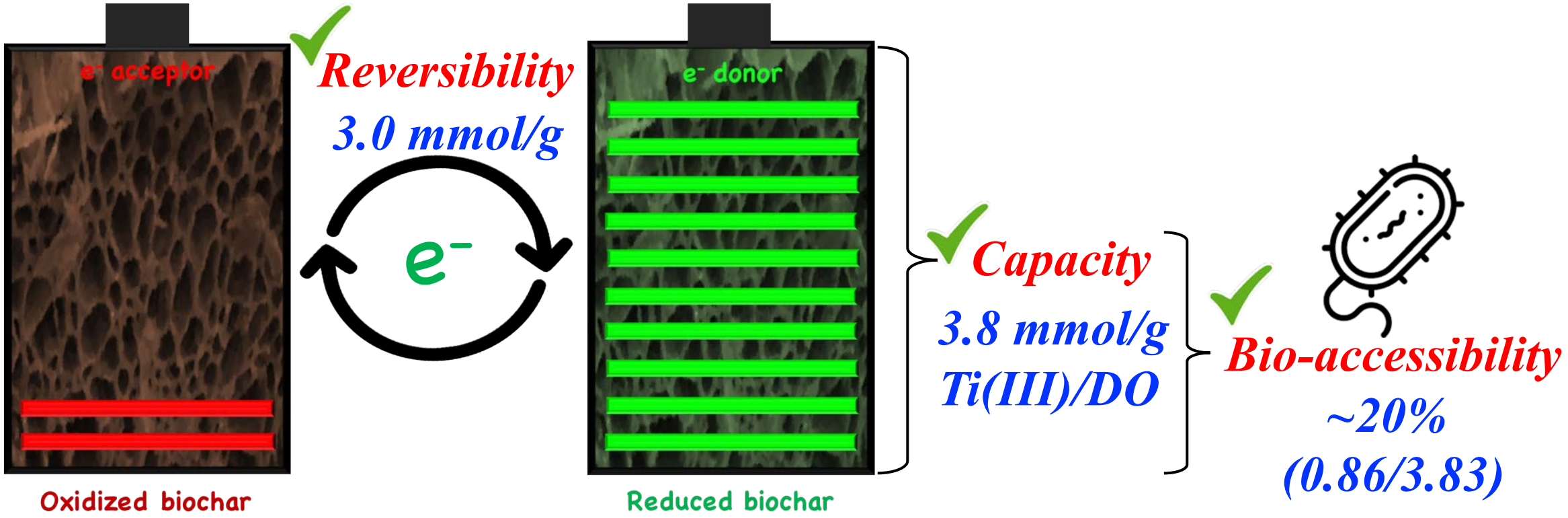
Reversibility of Biochar ESC



Arrows (↓) indicate where air oxidation of SRB was performed for 72 hours.

Takeaway

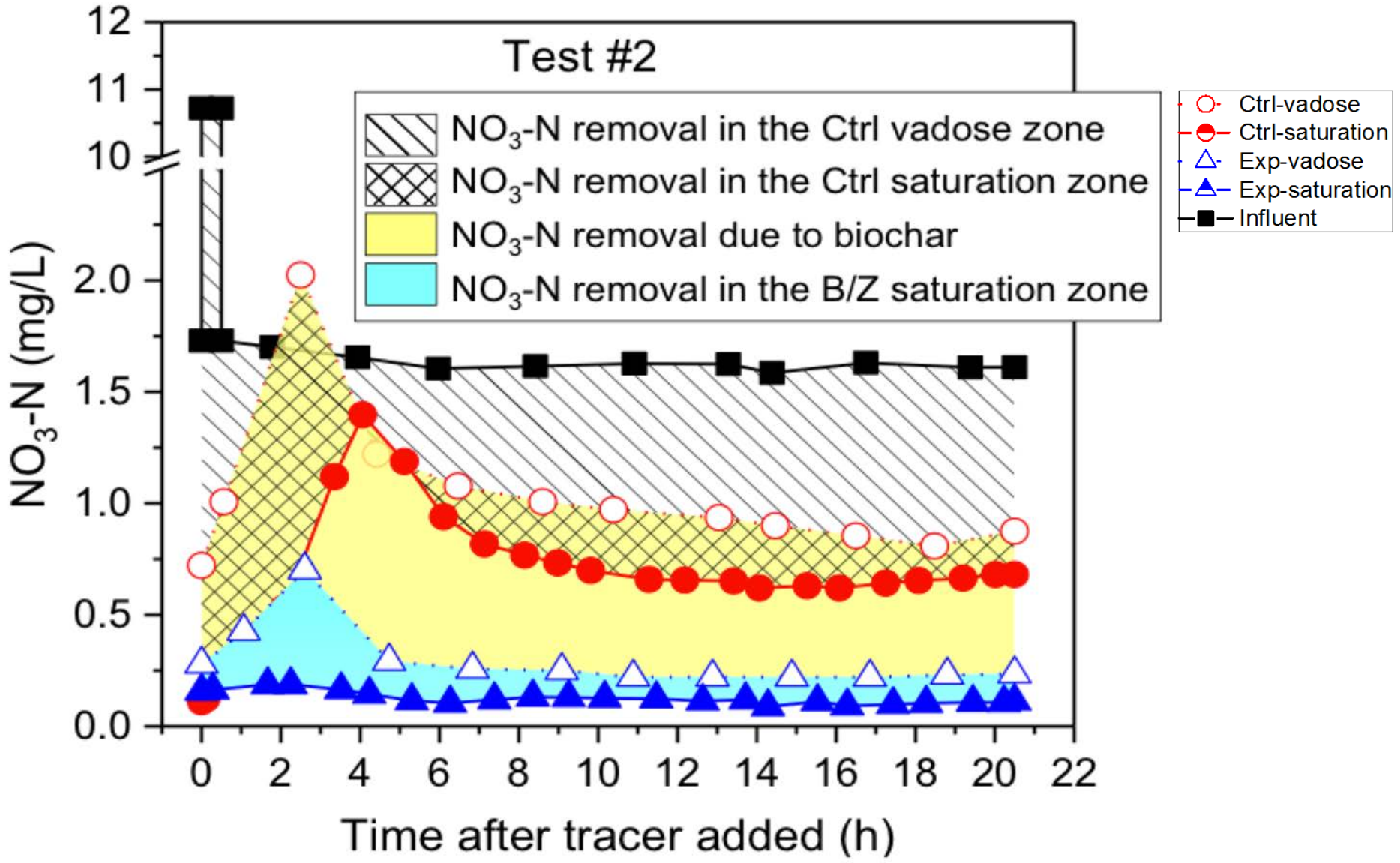
✓ **New methods for assessing ESC and redox reversibility of biochar**



Implications

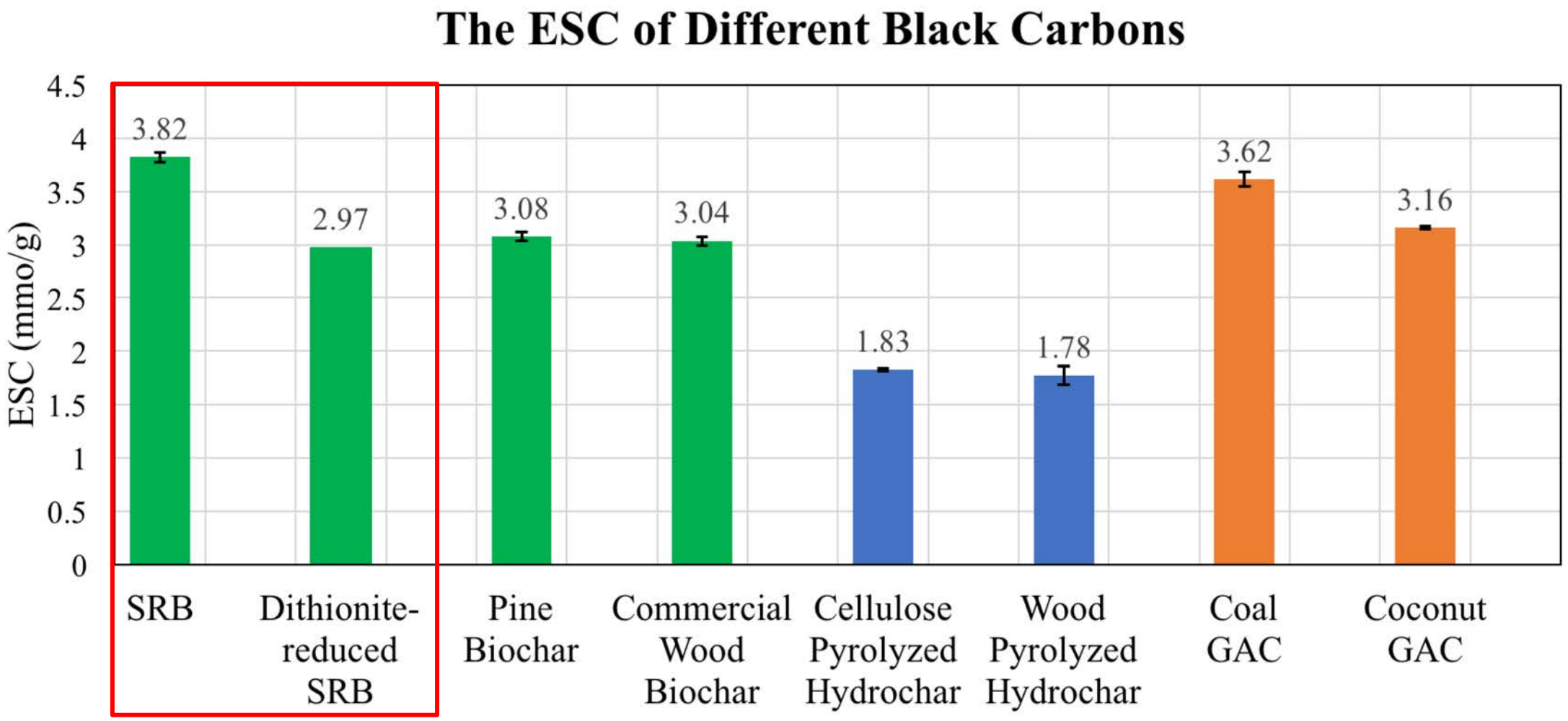
- A new method for assessing ESC and redox reversibility of black carbon material was developed.
- Like BET surface area, ESC may be a property that is common to biochar and other black carbon materials.
- ESC should be a design parameter for biochar applications that involve redox transformation.

Enhanced NO_3- Removal from Stormwater through Biochar and ZVI Addition



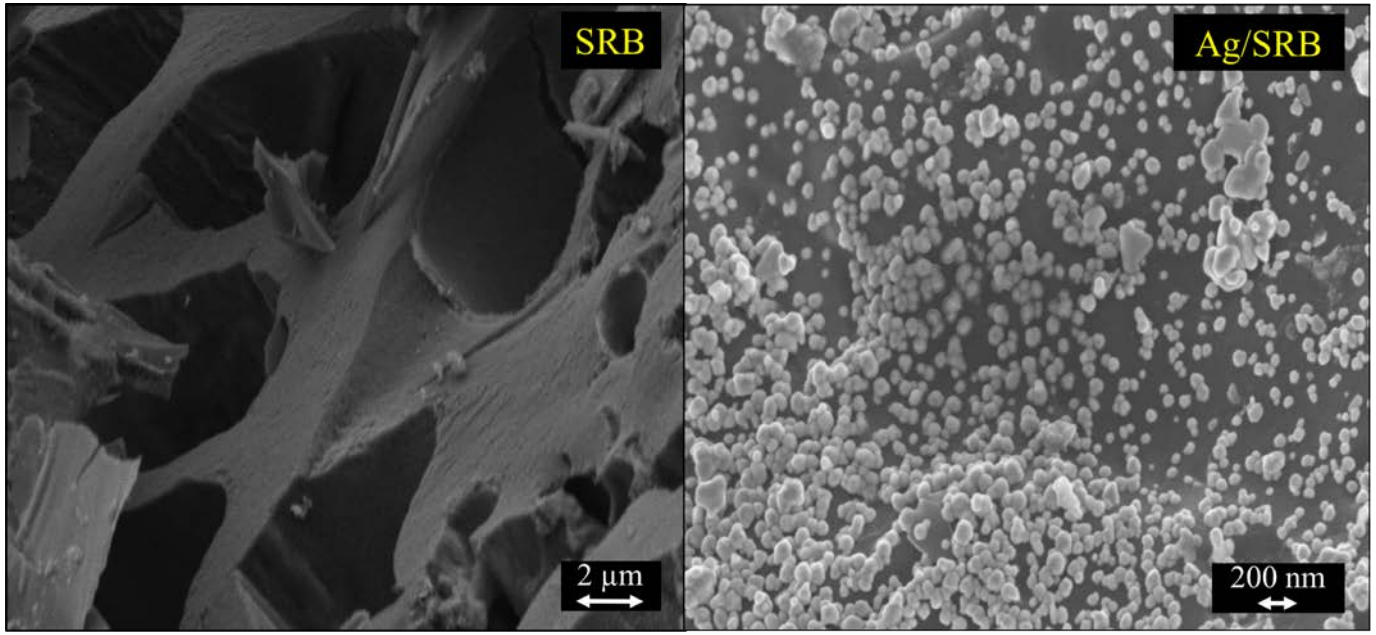
Tian, J.; Jin, J.; Chiu, P. C.; Cha, D. K.; Guo, M., Imhoff, P. T., A pilot-scale, bi-layer bioretention system with biochar and zero-valent iron for enhanced nitrate removal from stormwater. Water Res, In review.

Poster 26: ESC of Biochar and Other Black Carbon Materials

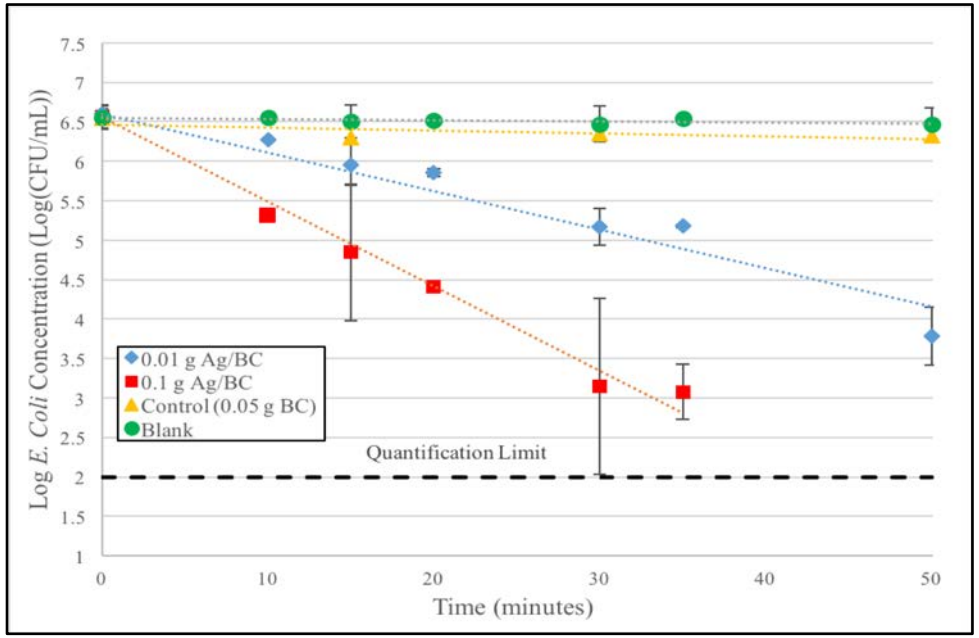


Poster 25: Biochar as a Nanoparticle Support Medium for Water Disinfection

A novel application of biochar's ESC



The effectiveness of Ag/SRB



Acknowledgements

Minghan Xian

Leslie Ope

Camila Babativa

USDA

CONSERVE

DELAWARE ENVIRONMENTAL INSTITUTE

UNIVERSITY OF DELAWARE

Keck CAAM @ UD

OHIO UNIVERSITY

UMBC

UNIVERSITY OF MARYLAND BALTIMORE COUNTY

1966

California-based company that produces biochar through a proprietary technology

Thank you for your attention!

Questions?

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