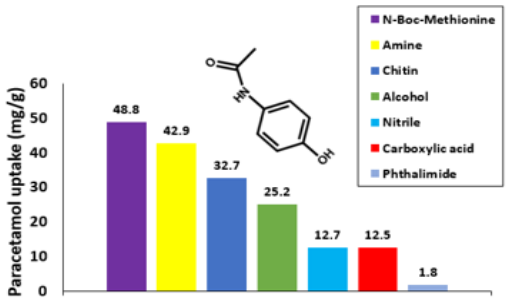
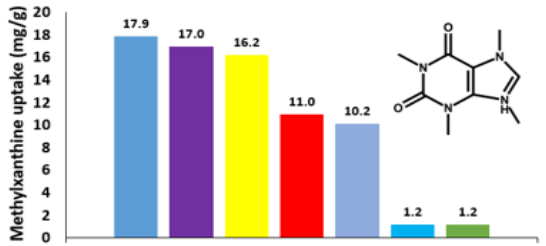
## Chitin Biopolymer for Adsorption

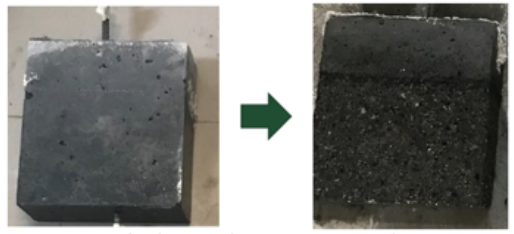
- Ligand functionalized chitin derivatives exhibit exceptional adsorption capabilities for aqueous paracetamol and methylxanthine
- The ligand structure to corresponding adsorption behavior demonstrates the customizability of the developed chitin adsorption system
- Some selectivity is noted, for example the alcohol chitin derivative shows a much higher uptake of methylxanthine than paracetamol (25.2 vs 1.2 mg/g)



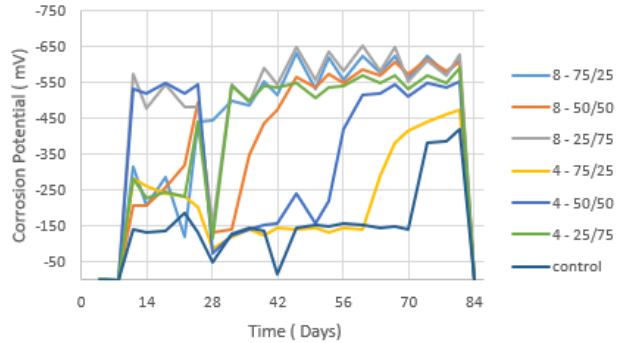

## Electrochemical Behavior of Biochar

- Measured electrochemical corrosion potential in 7 different mixes of biochar/bentonite concrete in 3 salt ponds (NaCl, $Ca(OH)_2$, $NaSO_4$
- Developed corrosion vs. time breakthrough curves
- 4% admixture containing 25 wt% biochar/75 wt% biochar performed best in the sodium chloride salt pond
- Compared potential values to established criteria for evaluating severity of corrosion occurring in concrete
- Developed understanding on how salt attack on concrete effects visual appearance and structural integrity



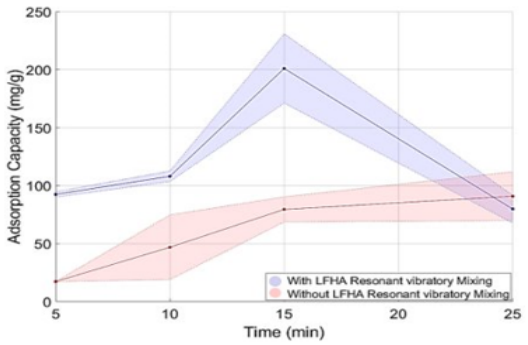
Salt scaling on sample set in NaSO4 over 12-week span

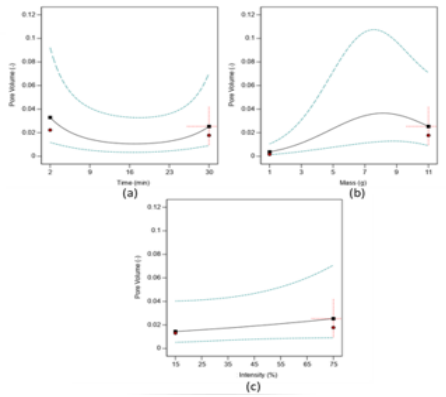
Potential vs Time for samples in NaCl




## Carbon Dioxide Sequestration

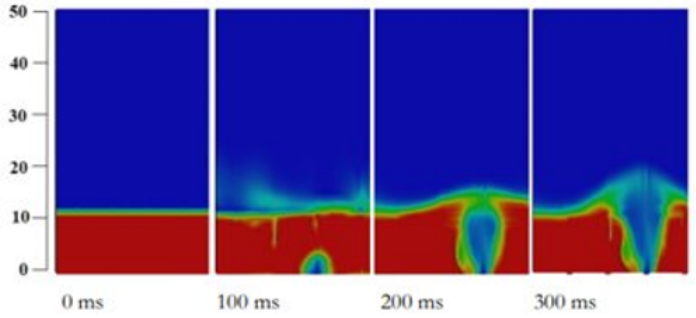
- Surface area changes during LFHA vibratory mixing will affect the behavior of $CO_2$ adsorption
- Similar $CO_2$ adsorption capacity is noted for both LFHA and no LFHA mixing at long times (25 min)
- Have both pore collapsing and milling behaviors
- For the short time intervals (t<16m), the decreasing trend indicates the collapsing effect is dominant which causes the pore volume to decrease.
- For longer time intervals, (t>16m), the grinding effect is dominant which produces fine particles.
- Fine particles result in more porosity which explains the pore volume increasing trend in the second half time.




## Predictive Biochar Production

- Multiphysics simulation pairing computational fluid dynamics (CFD) and discrete element modeling (DEM) software will model adsorption and LFHA vibratory mixing using CFD and build particle motion with DEM
- Dedicated computer with sufficient processing and graphics capability for model setup and preliminary calculations which will be introduced to Montana Tech's High-Performance Computer (HPC) center for more in-depth CFD calculations
- Altair Extended Discrete Element Modeling (EDEM) and Altair Acusolve was chosen for all calculations




Example CFD simulation of initialization of fluidization process

Feng, F. (2021). *Initial fluidization process from 0 ms to 300 ms for inlet position B* [simulation image]. Washington University. https://openscholarship.wustl.edu/cgi/viewcontent.cgi?article=1638&context=eng_etds

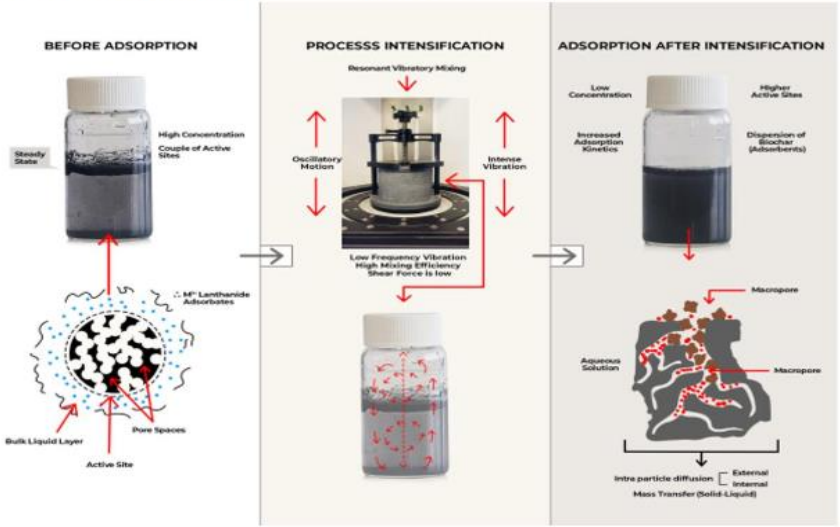
## Continuous Biochar Reactor

Dye Penetrant Welding Inspection Showing Passed (Right) and Failed (Left) Joints

Custom CNC Mill/Lathe Constructed to Machine Graphite Screw Auger

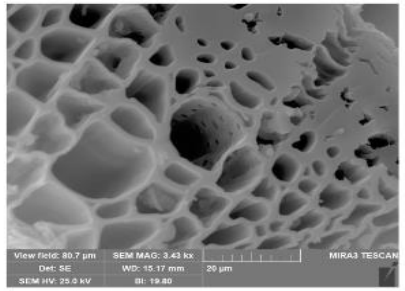
Partially Assembled Continuous Biochar Reactor

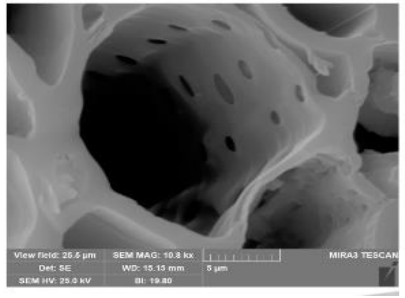
## Rare Earth Element Adsorption Process Intensification

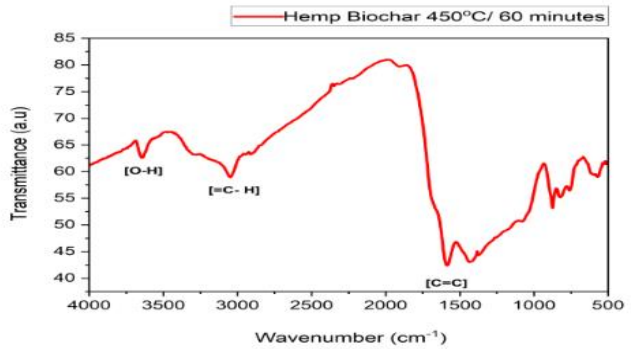



Phenomena of mixing and process intensification for solid-liquid separation of a material on biochar

## Solid Adsorbent Characterization








- SEM images (left) show the morphology and microstructure of the biochar adsorbent
- Clear, well-defined pores with high aspect ratios are observed
- DRIFTS spectra (right) shows the functional groups on the active sites for the biochar adsorbent
- These characterization methods coupled with BET N2 and CO2 physisorption will be utilized to determine adsorption uptake and adsorption kinetic behavior

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