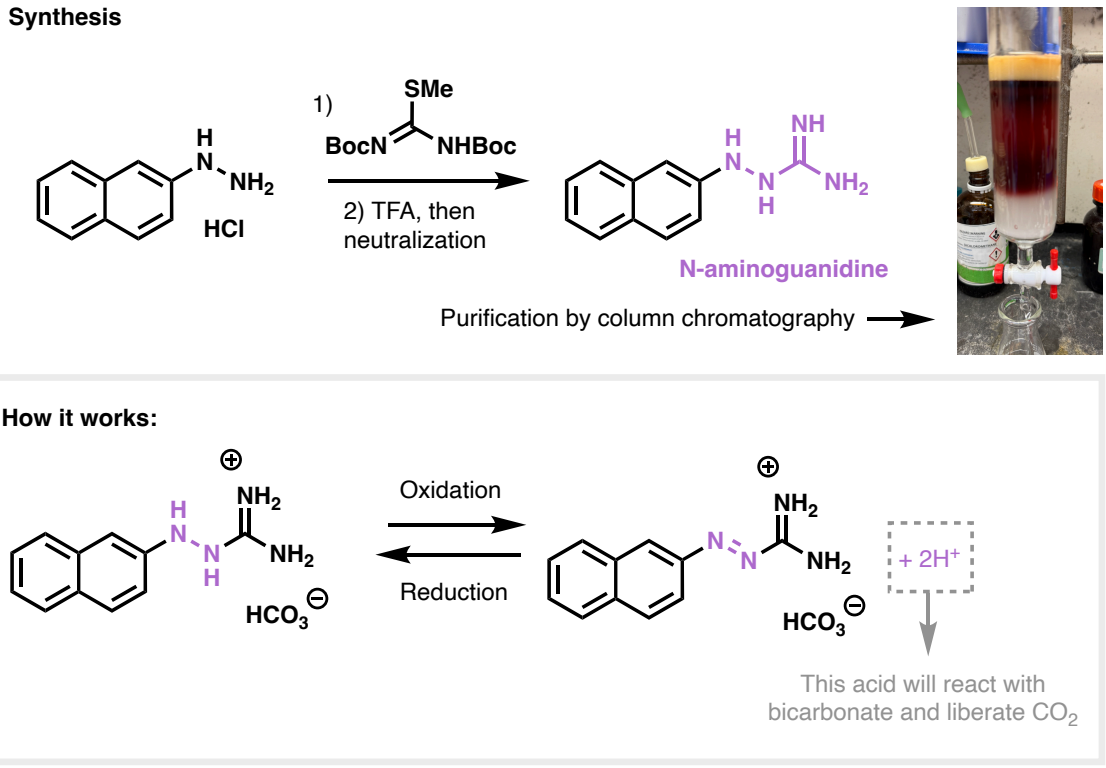
Milestones Achieved

The Direct Ocean Electrocapture (DOE) project aims to develop novel bicarbonate-absorbing materials—specifically metal-organic frameworks (MOFs)—for energy-efficient CO_2 capture from seawater. Although funding was received in March, roughly three months later than planned, we have already made substantial progress and are ahead of schedule.

While the original timeline projected that we would still be in the literature review phase, we have identified a promising and underexplored class of molecules: **N-aminoguanidines**, which exhibit both bicarbonate-binding capacity and redox activity—key features for electrochemically tunable CO_2 capture. Rather than beginning with MOF synthesis, we strategically prioritized the development of **key molecular building blocks** such as *N-aryl aminoguanidines* to first understand their stability, redox behavior, and bicarbonate absorption. This foundational work supports a more informed design of MOFs or polymer-based systems in later stages.

Initial synthesis is now underway, and we are excited to see how it behaves!



Schedule and Strategic Adjustment

Despite the initial funding delay, we have advanced into the molecular synthesis phase ahead of plan. Our next phase is MOF synthesis, but there is a key technical challenge: MOFs are typically obtained as microcrystalline powders, making structural characterization difficult. Without structural insight, molecular-level design is limited. To address this, we pivoted to **soluble organic gels or polymer scaffolds** that retain the functional motifs but are far more amenable to standard synthetic and analytical techniques. MOF development will follow once these structure-function relationships are well understood in these more tractable systems.

This shift allows us to investigate the core chemistry in a flexible and scalable format before transitioning to more rigid MOF structures.

Resources, Risk, and Outlook

To date, we've spent less than 10% of the grant funds—consistent with a front-loaded literature and design phase. With synthesis now underway, we anticipate allocating the remainder primarily to reagents and structural/electrochemical characterization. We have not yet formed external partnerships, preferring to establish a clear scientific foundation before seeking collaborators.

While we are not yet at the scaling stage, the building blocks have been designed for synthesis from inexpensive, commercially available materials, suggesting scalability should be viable—pending validation of their redox and bicarbonate-binding behavior. We are closely monitoring their performance as an early indicator of feasibility for larger-scale bicarbonate removal systems.

The main technical risk is that the synthesized molecules may not exhibit the desired redox responsiveness or bicarbonate binding. In that case, we will pursue mechanistic studies and, if needed, pivot quickly to alternative candidates. Although it is too early to project post-grant directions, the successful creation of a redox-active gel or polymer would represent a major inflection point, offering a clearer vision for both scalability and broader impact—and potentially forming the basis for future communications or outreach milestones.