Development of a Platform for Sustainable Metal-Organic Framework (MOF) Synthesis, MABIL: *MOF Automation using Biomass-Inspired Linkers*

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1. Introduction

Metal-Organic Frameworks (MOFs) are a class of porous materials comprised of organic linkers and inorganic metal nodes. In 2025, the Nobel Prize in chemistry was awarded to Kitagawa, Robson and Yaghi for their development of these materials.[1] MOFs have myriad applications including gas storage, energy storage and catalysis.[2] Their inherent potential and modular design make them ideal candidates for high-throughput design and synthesis.

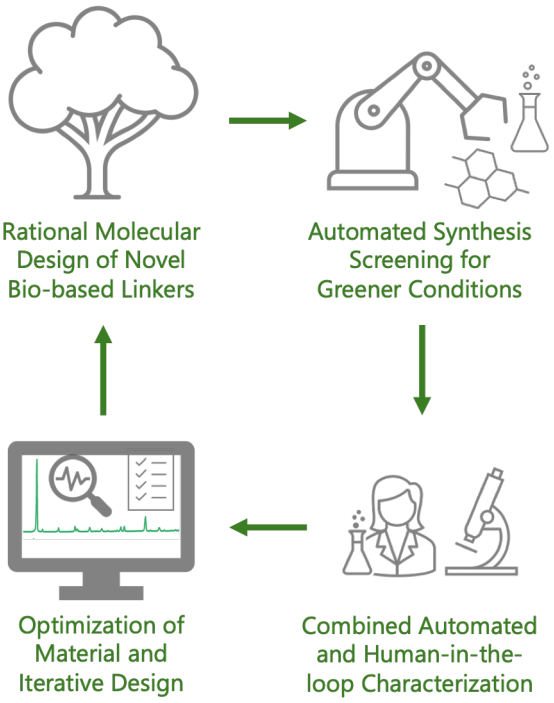
At present, a major drawback to MOF usage is their synthesis, often requiring harsh conditions, long reaction times, and toxic reagents, and solvents.[3] Additionally many of the linkers are petrochemically derived. As an alternative, biomass-derived linkers[4] present an opportunity to improve sustainability of MOFs in addition to identifying greener synthesis conditions. To achieve this goal of sustainable MOFs, a self-driving lab platform must be developed with appropriate screening techniques to automate and optimize the full synthetic process. In this work we have developed MABIL: MOF Automation using Biomass-Inspired Linkers.

2. Results and Discussion

To develop MABIL we used TORF-1 (Toronto Framework-1), a biomass-derived copper (II) MOF that we have recently prepared. TORF-1 can be made at room temperature in less than 10 minutes in green solvents. By starting with a liquid handling platform, we moved to a more accessible entry-level dispensing-pump system integrated with a commercially available CNC. Using this we added additional modules to monitor the MOF synthesis *in situ* and provide real-time insight.

We were able to reproduce our synthesis of TORF-1 using MABIL, with offline characterization to verify. Using a combination of data obtained from automated and human-in-the-loop characterization, we have optimized our material. We have been able to develop a further two copper (II) MOFs, TORF-2 and TORF-3 from biomass-derived linkers and optimization of these MOFs using MABIL is ongoing.

We have also extended the capability of the MABIL platform to improve the sustainability of previously reported MOFs, identifying new synthetic conditions that reduce reaction time, lower temperature and replace undesirable solvents.



3. Future Work

At present, MABIL has been developed to synthesise only copper (II) MOFs but with further improvements we will extend this to

other earth-abundant metal MOFs with broader chemical compatibility.

References

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