Covalent organic framework-based aerogel composites for passive atmospheric water harvesting

Brian Ridenour, Materials Science & Engineering
Mentor: Dr. Kailong Jin, Asst. Professor
School for Engineering of Matter, Transport and Energy

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Introduction

As global environmental trends continue to decrease the availability of clean freshwater, new methods are required to source water in arid environments. This research aims to produce covalent organic framework (COF)-based aerogel composites capable of cyclically harvesting atmospheric water in relative humidities below 20% (e.g. desert air in Arizona).

COFs are an emerging class of nanoporous, crystalline polymers with highly tunable microstructures. Typical synthesis methods yields a fine powder, which limits the diffusivity of fluids into the material, which in turn decreases the accessible functional surface area of the COFs. Aerogels are hierarchically porous networks with solid volume fractions below 10%, allowing for greater diffusivity. Synthesizing COFs as aerogels allows for more efficient diffusion into the material while maintaining the high surface area, porous structure of the COFs. The void spaces within the COF aerogel structure also allows for the incorporation of nanofillers to improve the gel's mechanical properties or provided expanded functionality.

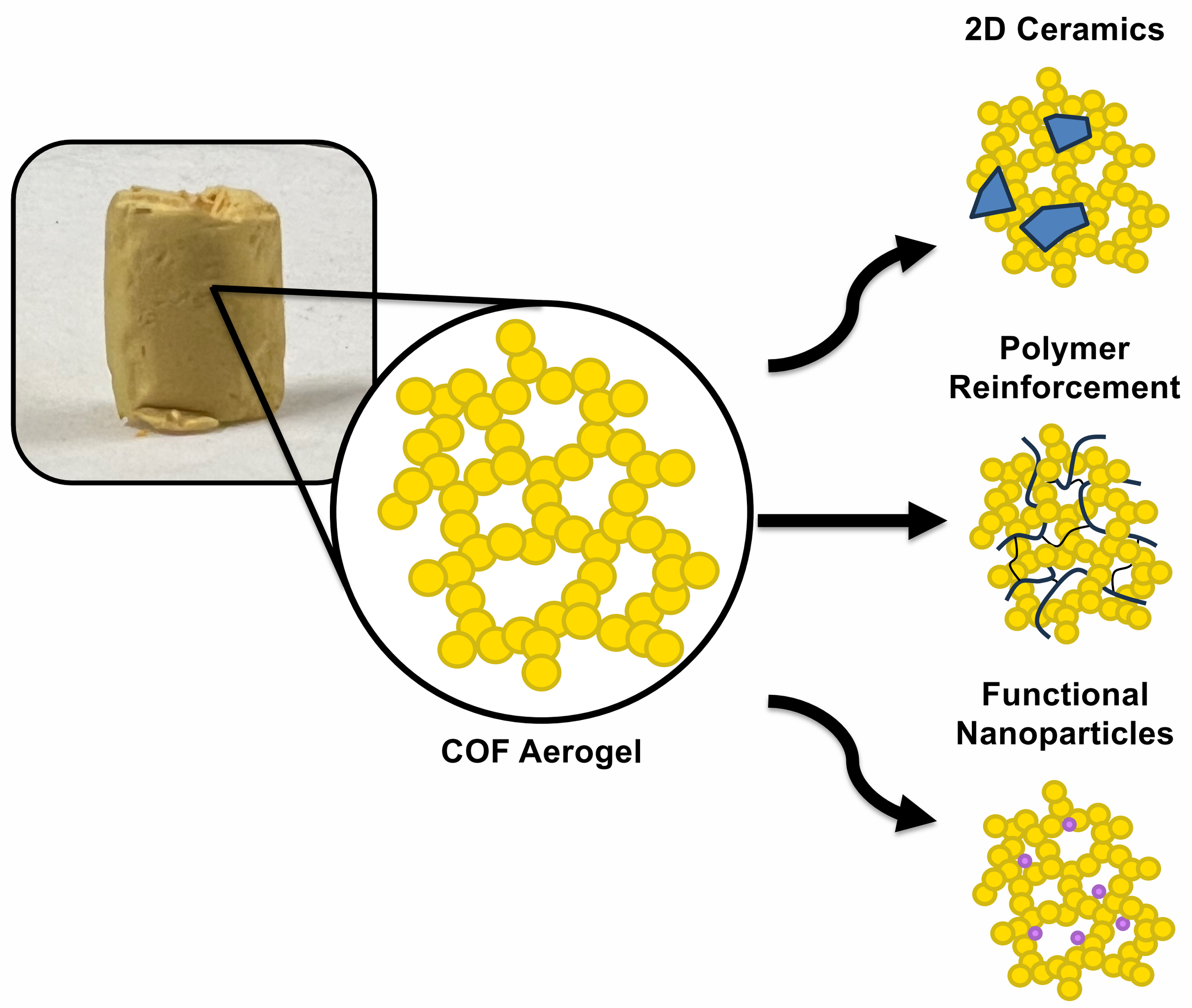

Figure 1. Overview of composite design displaying the classes of nanofillers being investigated. 2D ceramics (boron nitride) polymers (poly(acrylic acid) used to improve aerogel mechanical properties and gold nanoparticles used for photothermal energy conversion.

Methods

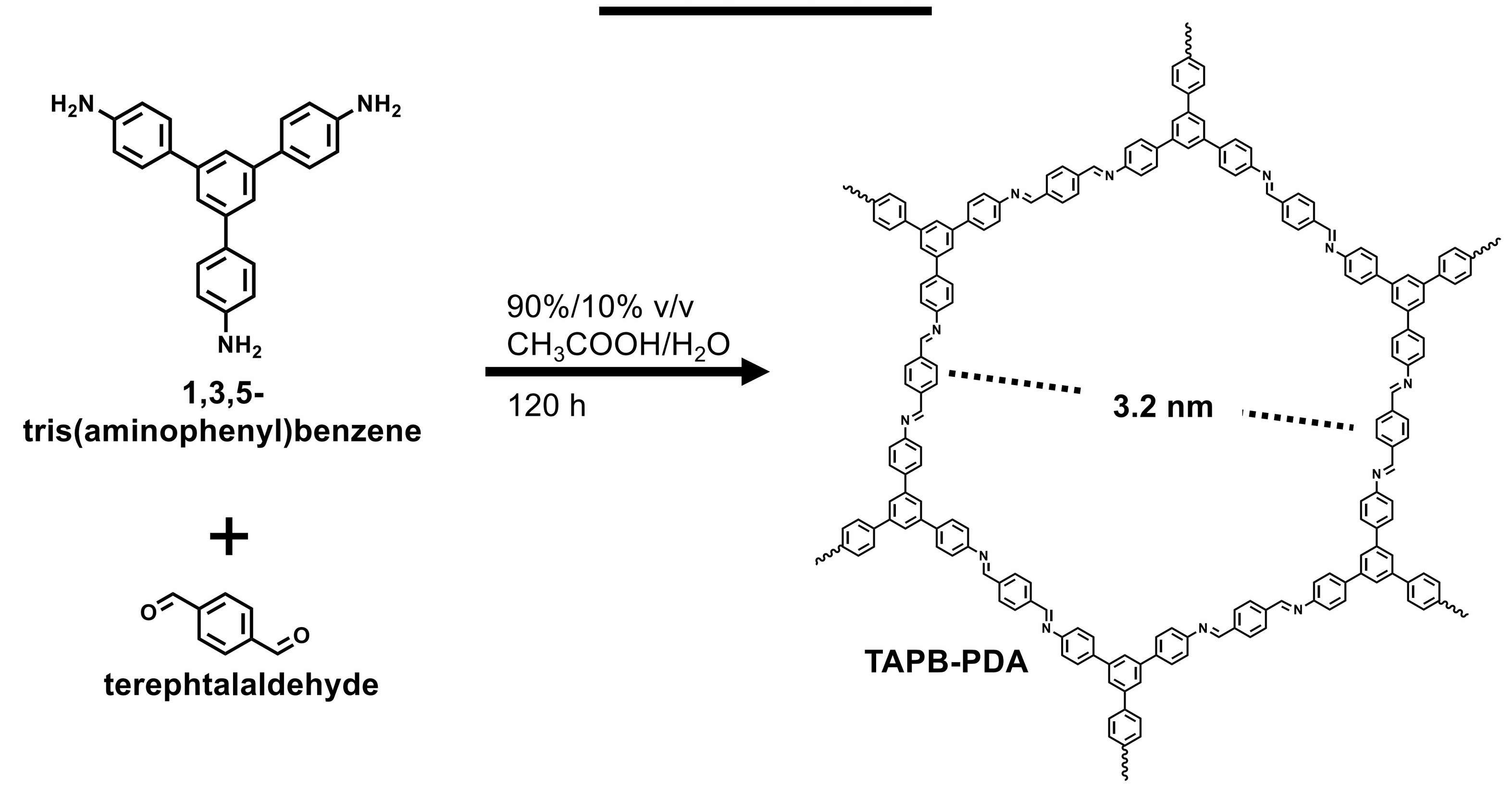

Figure 2. Synthesis of TAPB-PDA COF aerogel

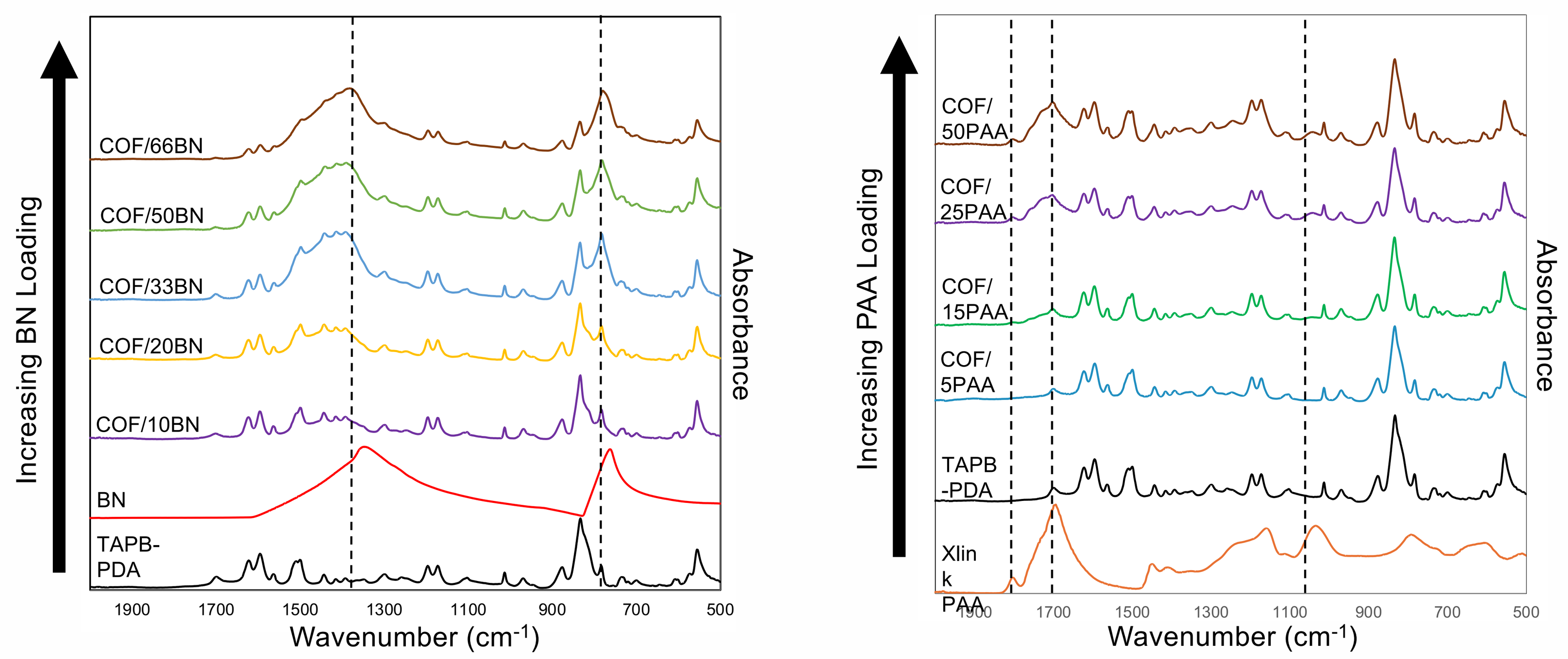

Figure 3. Confirmation of boron nitride and poly(acrylic acid) filler loading through Fourier transform infrared spectroscopy (FTIR)

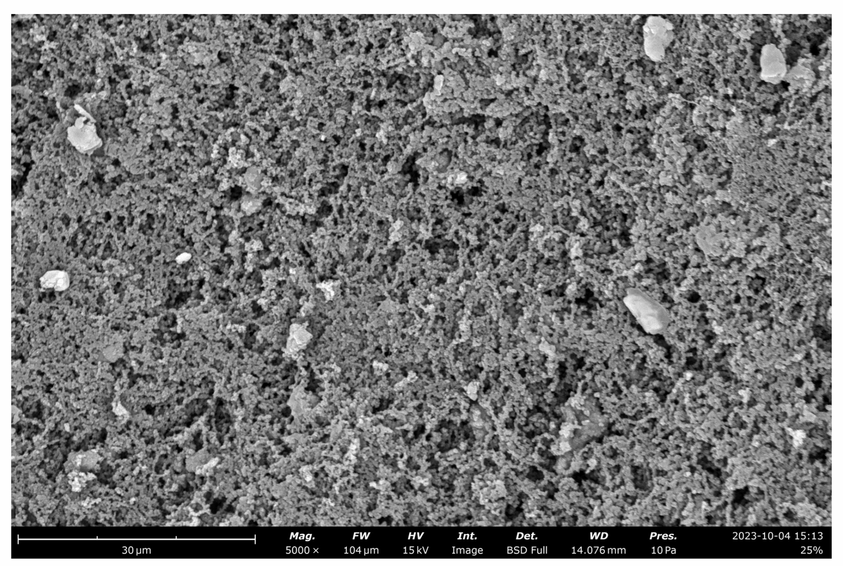

Figure 4. Visual confirmation of boron nitride loading via scanning electron microscopy.

Results and Discussion

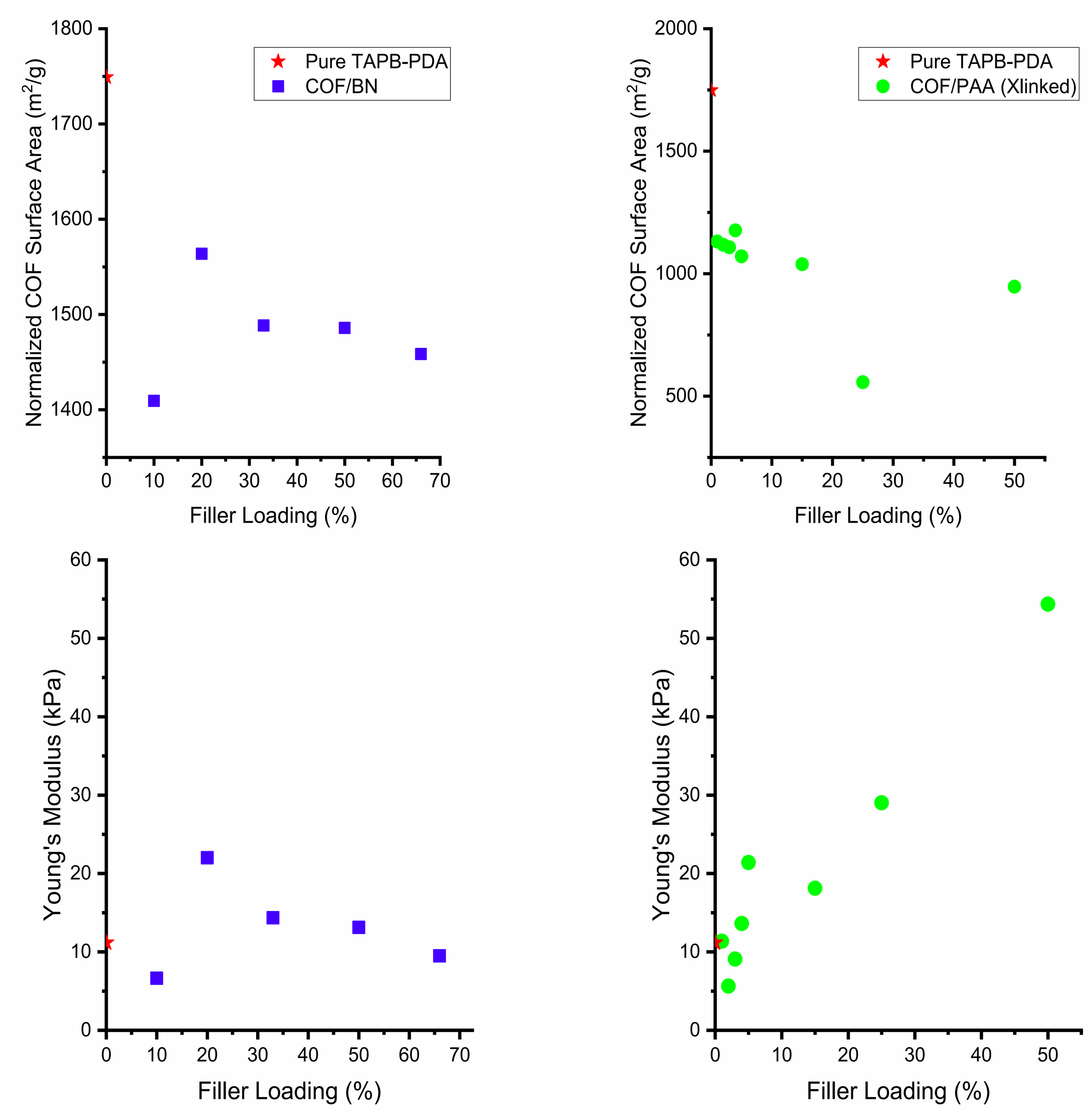

Figure 5. a) specific surface area of COF/BN and COF/PAA samples calculated from nitrogen adsorption spectra, normalized to the mass of COF within each composite sample. b) Young's moduli for each composite sample calculated from axial compression data. Modulus calculated from linear stress response from 0% to 20% strain.

Normalized specific surface area decreased proportional to the nanofiller loading, indicating the blocking of nanoporous channels within the COF particles. Boron nitride failed to have a major impact on the mechanical properties of the composites, while poly(acrylic acid) resulted in materials with significantly higher elasticities and Young's moduli compared to the pure aerogel.

References

Martin-Illan et al., *Ange. Chem.*. **2021** 60 (26), 13969-1397
Shanmuganathan & Ellison, *ACS App. Mat.* **2015** 7 (11), 6220-6229