ASU's DAC polymer-enhanced cyanobacterial bioproductivity (AUDACity)

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Increasing the concentration of CO_2 delivered to photosynthetic microbes can greatly improve their productivity. We propose a novel direct air capture (DAC) technology that integrates newly developed CO_2-capture polymers to continuously and rapidly deliver inorganic carbon (C_i) directly into the cultivation medium to maximize photosynthetic growth rates and produce sustainable fuels and high-value products with the CO_2 delivered by DAC; we call this technology ASU's DAC polymer-enhanced cyanobacterial bioproductivity (AUDACity, **Figure A**).

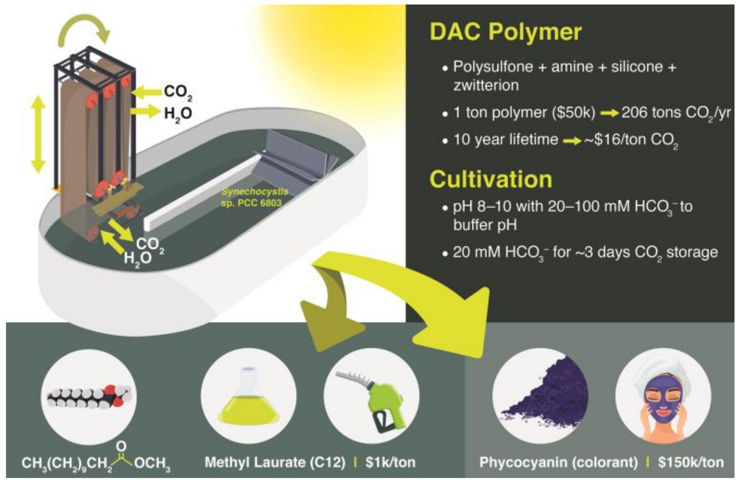

Figure A. AUDACity uses a novel DAC-polymer for capturing CO_2 from air and directly delivering to a culture of photosynthetic microbes at scale for producing sustainable fuels and valuable products, such as methyl laurate and phycocyanin.

The CO_2-capture polymer builds on the principles of moisture-swing sorption observed in well-established quaternary ammonium-based anion exchange resins; they capture CO_2 from air when dry and release C_i when exposed to moisture. The DAC-polymer material introduces quaternary ammoniums for rapid CO_2 capture into high-surface-area, porous poly(arylene ether sulfone)s (PAES) polymers for rapid CO_2 capture from air, with high flexibility and stability to withstand tensions and torsion as it is continuously circulated between exposure to air and the cultivation medium (Figure A). AUDACity will be used to provide C_i to cultivate biofuel-producing cyanobacteria, specifically *Synechocystis* sp. PCC 6803 strains developed at ASU that have been engineered to excrete laurate and methyl laurate ($1k/ton) and that contain phycocyanin, a high-value natural dye for food and cosmetics ($150k/ton). To further improve performance, the DAC-polymer will be optimized to resist biofouling, minimize salt exchange with the cultivation medium (made from either fresh water or sea water) that could degrade its performance, and minimize polymer drying time to maximize the polymer's cycling frequency between air and cultivation medium. AUDACity systems, which are integrated to include both polymers and cyanobacterial culturing, will be evaluated in terms of DAC-polymer material performance, biocompatibility, kinetics of CO_2 delivery from air to the culture, and pH stability. Scales of cyanobacterial culturing will range from laboratory scale to outdoor ponds (Figure A).

The project's ultimate objective is to demonstrate a pathway for delivering CO_2 from air to photosynthetic microbes for ~$50/ton or less at rates that do not limit their growth. This low cost is enabled by the use of low-cost polymers and by eliminating forced air movements and CO_2 compression and delivery. Our AUDACity concept overcomes significant CO_2 losses associated with sparging (up to 70% loss) and significantly reduces the CO_2 delivery cost compared to other emerging DAC technologies.