Towards a Closed Carbon Cycle: Novel Organic Microparticles & Encapsulants for Carbon Dioxide Capture & Conversion to Value Added Products

Das, Autri (School: Sunset High School)

Carbon dioxide (CO2) emissions have devastating impacts on agriculture, human life, and the environment. This research developed the first-ever cost-effective, environmentally sustainable materials and systems level innovation towards a closed carbon cycle system effectively combining CO2 capture, conversion to value added products, and storage in a single system composed of micro-gel pellets treated with microbubbles and nitrogen doped ammonium citrate dibasic microparticles (ACD MPs). Multi-functional ACD MPs (i) enhance CO2 capture by increasing gel porosity and (ii) act as an electrocatalyst for conversion of CO2 to value-added products (hydrocarbons) which are then stored in gel pellets. Microbubbles facilitate mass transfer of CO2 via diffusion for capture of CO2 directly from air. Formulation reduces cost compared to commercial solutions by 81%. Computational simulation of CO2 localization using statistical mechanics at ambient and microencapsulated conditions reinforce the diffusive effect of gel formulation. Three systems were tested with custom pressure sensor circuit setup and capture performances were compared relative to water: (i) gel pellets: 9x higher performance, (ii) gel pellets/ACD MPs: 31x higher, (iii) gel pellets/ACD MPs/microbubbles: 42x higher. Characterization via FTIR and optical microscopy proved gel pellets/ACD MPs bonding. Zetasizer showed gel pellets were ~1.6 micron and ACD MPs were ~2.3 micron. Pressure gradient proved as microbubbles on gel pellet surface caused 25 Pascal drop in gel pellets. NMR data showed CO2 reduction into hydrocarbons via gel pellet/ACD MPs/microbubble system. Thus, proposed gel pellet/ACD MP/microbubble is a first-ever materials/systems level innovation combining capture, conversion, and storage into one system.

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