Electrocatalytic CO_2 Reduction to Formate for Renewable Energy Storage Applications

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Electroreduction of CO_2 to formate ($HCOO^-$) is one of the most intensely studied pathways for CO_2 utilization. The product formate salt (e.g., Na or K) solution can be utilized as a convenient energy vector for applications in fuel cells and batteries. The bifunctional (or bidirectional) electrode for reversible CO_2 conversion to formate is essential for development of novel energy storage technologies such as CO_2 redox flow batteries and reversible formate fuel cells. The presentation reviews recent advances in electrocatalysis and electrode engineering for CO_2 reduction to formate and formate electro-oxidation to carbonate. A major advantage of CO_2 based electrochemical energy storage is the several orders of magnitude lower cost of CO_2 compared to any metal (e.g., lithium, cobalt, nickel, zinc) used in batteries. Furthermore, it offers a new and viable business case for CO_2 utilization, namely, long-duration and large-scale energy storage with a market that is estimated to grow fifteen-fold between 2022 and 2030. Results will be discussed showing the evolution of the CO_2 redox flow battery from fundamental electrocatalysis to the engineering of 100 cm^2 electrode area flow cells. The experimental results are contextualized within a techno-economic analysis assessing the viability of different electrochemical CO_2 utilization pathways.