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Amine Sulphonic Acid Additives for Improving Energy Storage Capacity in Alkaline Gallocyanine Flow Batteries

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Abstract : Transitioning to a renewable energy model is inevitable owing to the effects of climate change. These energies are aimed at sustainability and a positive impact on the environment, but they are intermittent energies; their connection to the electrical grid depends on creating long-term, efficient, and low-cost energy storage devices. Redox flow batteries are attractive technologies to address this problem, as they store energy in solution through external tanks known as posolyte (solution to storage positive charge) and negolyte (solution to storage negative charge). During the charging process of the device, the posolyte and negolyte solutions are pumped into an electrochemical cell (which has the anode and cathode separated by an ionic membrane), where they undergo oxidation and reduction reactions at electrodes, respectively. The electrogenerated species should be stable and diffuse into the bulk solution. It has been possible to connect gigantic redox flow batteries to the electrical grid. However, the devices created do not fit with the sustainability criteria since their electroactive material consists of vanadium (material scarce and expensive) solutions dissolved in an acidic medium (e.g., 9 mol L-1 of H_2SO_4) that is highly corrosive; so, work is being done on the design of organic-electroactive electrolytes (posolytes and nogolytes) for their operation at different pH values, including neutral medium. As a main characteristic, negolyte species should have low reduction potential values, while the reverse is true for the oxidation process of posolytes. A wide variety of negolytes that store 1 and up to 2 electrons per molecule (in aqueous medium) have been publised. Gallocyanine compound was recently introduced as an electroactive material for developing alkaline flow battery negolytes. The system can storage two electrons per molecule, but its unexpectedly low water solubility was improved with an amino sulphonic acid additive. The cycling stability of and improved gallocyanine electrolyte was demonstrated by operating a flow battery cell (pairing the system to a posolyte composed of ferri/ferrocyanide solution) outside a glovebox. We also discovered that the additive improves the solubility of gallocyanine, but there is a kinetic price to pay for this advantage. Therefore, in this work, the effect of different amino sulphonic acid derivatives on the kinetics and solubility of gallocyanine compound was studied at alkaline solutions. The additive providing a faster electron transfer rate and high solubility was tested in a flow battery cell. An aqueous organic flow battery electrolyte working outside a glovebox with 15 mAhL-1 will be discussed. Acknowledgments: To Bi3BoostFlowBat Project (2021-2025), funded by the European Research Concil. For support with infrastructure, reagents, and a postdoctoral fellowship to Dr. Martínez-González.

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