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High performance polyvinyl alcohol/calcium titanate nanocomposite anion-exchange membranes as separators in redox flow batteries

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Abstract Low ionic conductivity and poor chemical stability are the two key parameters that limit the use of many anion-exchange membranes in electrochemical applications like rechargeable batteries and fuel cells. Herein we report a method for the synthesis of a high performance anion-exchange membrane fabricated by incorporating calcium titanate nanoparticles ($CaTiO_3$) into polyvinyl alcohol (PVA) matrix. The $CaTiO_3$ was synthesized by a new co-precipitation method from a solution of two simple precursors, viz potassium titanyl oxalate and calcium chloride. The XRD data of the synthesized nanoparticles indicate a phase pure orthorhombic perovskite structure. Morphological features investigated with SEM and TEM studies, reveal that the $CaTiO_3$ is having spherical shape with a diameter of approximately 200 nm. The PVA/$CaTiO_3$ nanocomposite membranes were fabricated by solution casting method from a well dispersed suspension of $CaTiO_3$ in PVA and characterized by FT-IR spectroscopy, TGA, SEM, AC impedance analysis and tensile strength measurements. The membranes with 30 wt% $CaTiO_3$ content possess ionic conductivity of 66 mS cm^{-1} at room temperature. The electrochemical performance of an all-iron redox flow cell was studied using galvanostatic charge–discharge tests using the above nanocomposite membrane as separator and the system exhibited a coulombic efficiency of 75% during the charge–discharge cycles.

Keywords Calcium titanate · Anion-exchange material · PVA/$CaTiO_3$ nanocomposite · Anion-exchange membranes · All-iron redox flow battery

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