Transport Numbers of Ion-Exchange Membranes in Divalent Sulfate Electrolytes for Lithium- Ion Battery Recycling Applications

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Recycling spent lithium -ion batteries (LIBs) is essential for addressing environmental and resource challenges through the recovery of valuable materials. Electrodialysis has emerged as a promising electro-membrane strategy for the selective recovery of resources from spent LIBs. In particular, the separation of metals from leaching solutions of spent LIBs using electrodialysis with ion-exchange membranes (IEMs) has been proposed as a route for LIB recycling. Ion transport in IEMs plays a critical role in determining the efficiency and selectivity of ions in electro-membrane processes. This study presents the first investigation of transport properties, including ionic transport numbers and water transference coefficients, of Ni (II) and Co (II) ions across commercial IEMs using NiSO4 and CoSO4 electrolyte solutions, relevant to electrodialysis applications and recycling of LIBs. The permselectivity analysis was employed for the analysis of new electric potential measurements across Selemion IEMs in contact with aqueous NiSO4 and CoSO4 solutions within the framework of non-equilibrium thermodynamics. The transport numbers obtained for Ni (II) and Co (II) ions in sulfate salt solutions were 1.000 ± 0.006 and 1.003 ± 0.008, respectively, indicating high membrane selectivity and near-ideal transport behavior for these divalent sulfates. The corresponding water transference coefficients were found to be 16 ± 2 and 15 ± 3. These findings highlight the importance of accounting for water transport in the design of electrodialysis for antisolvent recovery in hydrometallurgical recycling of LIBs. The presented method can further support the development of efficient membranes for specific electro-membrane processes.