SILAR-Assisted Binder-Free Growth of Iron Tungstate/Reduced Graphene Oxide Composite Thin Films for Energy Storage Applications

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Abstract
In the context of sustainable energy generation and the growing global demand for next-generation energy storage systems, this study reports the successful binder-free synthesis of an iron tungstate/reduced graphene oxide ($FeWO_4$/rGO) composite thin film electrode using a facile successive ionic layer adsorption and reaction (SILAR) method. A five-beaker cost effective SILAR system comprising aqueous rGO dispersion and iron- and tungstate-precursor solutions was employed to achieve uniform deposition of iron tungstate nanostructures on rGO surface. X-ray diffraction analysis confirmed the retention of the monoclinic crystal structure of $FeWO_4$, while slight peak broadening and intensity variations after rGO incorporation indicate reduced crystallite size and strong interfacial interactions between $FeWO_4$ and rGO. FE-SEM and TEM analyses revealed a morphology consisting of interconnected nanoflakes embedded with well-defined nanorods of $FeWO_4$, uniformly grown on rGO nanosheets, forming a nanoflake–nanorod on nanosheet composite architecture. The synthesized binder-free $FeWO_4$/rGO composite thin film electrode exhibited excellent electrochemical performance in 1 M KOH electrolyte, delivering a high specific capacitance of 385.2 F g^{-1} at a current density of 1 A g^{-1}. These results demonstrate the strong potential of the $FeWO_4$/rGO composite thin film as anode for next-generation energy storage applications.