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Solution combustion synthesis of mixed-phase Mn-based oxides nanoparticles and their electrocatalytic performances for Al-air batteries

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Abstract: Mn-based mullite oxides have been proposed as outstanding oxygen reduction reaction catalysts (ORRCs) to substitute the noble metal. However, the most reported synthesis methods for the mullite oxides were complicated with a very long cycle and low yield. In this work, we firstly used sol-gel solution combustion adding one step calcination method to large-scale synthesize mixed-phase and pure-phase mullite oxides ($SmMn_2O_5$) with detailed synthesis process. The structure and morphology of samples were investigated by XRD, SEM and TEM. Comprehensive study of nanoparticles synthesized under different calcination conditions showed that mixed-phase catalyst based on $SmMn_2O_5$ and perovskite ($SmMnO_3$) were obtained under the 800°C calcination and the content of $SmMn_2O_5$ was proportional to the calcination time and inversely related to the ratio φ. Pure-phase $SmMn_2O_5$ could be obtained at a calcination temperature above 900°C. The electrocatalytic activities of φ=1 catalysts for oxygen reduction reaction (ORR) were characterized by a three-electrode design and the full dischargeable Al-air battery with 4M NaOH electrolyte. Electrocatalytic characterization showed that the presence of $SmMn_2O_5$ combined with perovskite $SmMnO_3$ exhibited the best catalytic activity, and the sequence of activity was as follows: $SmMn_2O_5$ – 800 4h > LMO ($La_{0.96}Mn_{0.96}O_3$) > $SmMn_2O_5$ – 900 4h > $SmMn_2O_5$ – 1000 4h > CB (carbon black).

Keyword:
Electrode materials; Nanostructured materials; Oxide materials; Sol-gel processes; Catalysis