Exploring the impact of temperature variation on the specific surface area evolution of hydrothermally synthesized MnO_2 for supercapacitors application

Vania Ilcheva, Borislava Mladenova, Victor Boev, Mariela Dimitrova, Ognian Dimitrov, Elefteria Lefterova, Antonia Stoyanova
Acad. Evgeni Budevski Institute of Electrochemistry and Energy Systems, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 10, Sofia 1113, Bulgaria

Manganese dioxide is well known technologically attractive and extensively researched material, offering variety of applications due to its polymorphic variations. The physicochemical and surface characteristics of MnO_2, important for its electrochemical behaviour, are tightly related to its crystalline structure, particles size and morphology. Consequently, this material in different polymorphs attracts substantial attention as an electrode material among different energy storage systems, including alkaline batteries, Li-ion batteries, and supercapacitors.

This work represents the possibility of modifying the phase structure and morphology of hydrothermally prepared MnO_2 by variation of the synthesis temperature. Our main objective is to clarify the impact of the synthesis conditions on the specific surface area of the final material, thereby assessing its potential suitability as an electrode material in hybrid supercapacitors. The hydrothermal synthesis of the MnO_2 nanostructures was performed using initial aqua solutions of $KMnO_4$ and $MnSO_4{\cdot}H_2O$, subjected to varying temperatures (100, 120, 140, 160, 180 °C).

Phase composition analysis was conducted via X-ray diffraction (XRD), while scanning electron microscopy (SEM), transmission electron microscopy (TEM) and selected area electron diffraction (SAED) were employed for morphology and structural characterization. Specific surface area was determined using the Brunauer-Emmett-Teller (BET) method, with total pore volume calculated following Gurwitsch's rule. The pore size distribution was estimated using the Barrett-Joyner-Halenda method.

The XRD patterns prove the formation of α-MnO_2 crystallographic phase together with co-formed intercalating compound $K_{0.27}MnO_2{\cdot}0.54H_2O$ at elevated temperature.

The results obtained demonstrate the highest specific surface area (156.7 m^2/g) of the sample thermally annealed at 160 °C among the series under investigation. This observation motivates further exploration of the electrochemical properties of this mixed phase to elucidate its potential as an electrode material in solid-state supercapacitors.

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