This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 101035813

Facile synthesis of sulfurized MoO_3 nanostructures from industrial waste powder for energy storage application

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The green transition required by climate change also involves the development of more environmentally friendly and efficient energy storage devices. The use of industrial waste to produce nanostructured functional materials is a crucial strategy for mitigating environmental issues. Industrial waste powder rich of Mo attract a lot of interest thanks to the catalytic properties of Mo-based oxides and sulphides. Here, we report a novel, low-cost synthesis consisting in a two-steps hydrothermal process to obtain sulfurized MoO_3 (MoS_2/MoO_3) nanostructures starting from Mo-based industrial waste powder. Scanning electron microscopy, Transmission electron microscopy, Raman spectroscopies, X-Ray Diffraction pattern and Rutherford backscattering spectrometry have been used for physical-chemical characterization. The first step concerns with the MoO_3 nanobelts (50-200 nm wide, 10 µm long) synthesis from a peroxo-molybdate solution, obtained by mixing Mo-based starting powder with H_2O_2. The morphology of MoO_3 nanobelts strongly depends on the hydrothermal bath pH. The MoO_3 nanostructures have been sulfurized into MoS_2/MoO_3 nanostructures (200 nm wide) by a second hydrothermal treatment and with the addiction of thiourea in solution. MoS_2/MoO_3 nanostructures were tested for energy storage applications using Cyclic Voltammograms (CV) and Galvanostatic Charge-Discharge (GCD) measurements within neutral electrolyte (1 M Na_2SO_4) without the addiction of binder. High specific capacitance values were recorded for these nanostructures, 218 F g^{-1} and 120 F g^{-1} respectively at 5 mV s^{-1} and 0.5 A g^{-1}. These promising results open a way to large scale application of recycled materials for energy storage.