The New Solid State Mechanochemical Synthesis of Advanced Ni, Ni-Co and Ni-Al Hydroxides for Hybrid Supercapacitor Application

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Hybrid supercapacitors with nickel hydroxide electrodes are widely used as modern power sources for starting and working of different types of electric motors, especially in electric vehicles, computer and equipment UPS, etc. Current research project suggests production principle of novel low water solid state mechanochemical synthesis of advanced Ni, Ni-Co and Ni-Al hydroxides with high electrochemical activity. Coffee grinder, as low-energy activator, was used for mechanochemical synthesis of hydroxide samples from hydrated or anhydrous salt precursors. Synthesized samples were analysed by PXRD, TG, DSC, SEM, EDX, voltammogramm and charge-discharge cycling. It was established that all samples are β-Ni(OH)2 by PXRD, TG, DSC methods. The direct formation of Ni(OH)2 during of mechanochemical synthesis and obtaining of 4Ni(OH)2·NiOOH and NaNiO2 was proved with PXRD. Hydrate synthesis sample is sodium-doped Ni(OH)2 with nano-thickness (14 nm) hexagonal particles, anhydrous synthesis sample is sulfate-doped Ni(OH)2 with spherical morphology. Voltammograms and charge-discharge cycling exhibited the highest electrochemical activity of the anhydrous synthesis Ni(OH)2, and Ni-Co and Ni-Al hydroxide samples obtained from sulfate precursors. The specific capacities are 802.7, 1332.8, 1072.2 F/g at 1-2 C and 196.7, 447.4, 404.8 F/g at 15-20 C respectively. From Regone diagram, maximum energy and power densities are 34.9 kW/kg-265.2 W*h/kg and 43.1 kW/kg-400 W*h/kg (for Ni-Al and Ni-Co hydroxides respectively). Conclusion. Suggested solid state mechanochemical synthesis, especially from sulfate anhydrous precursors, by low-energy activator (like coffee grinder) is perspective method for obtaining of the advanced Ni, Ni-Co and Ni-Al hydroxides for supercapacitor’s applications.