Synthesis of Ni_2P/C nanofibers as anode materials for lithium-ion batteries

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Transition metal phosphides as anode material for Lithium-ion batteries had widespread attention due to their lower polarization, larger capacity and good cycling behavior [1-3]. Moreover, the higher theoretical capacity of Ni-P systems according to their phosphorus number makes them more attractive compared to oxides or sulfides. In this work, Ni_2P/C nanofibers were synthesized using a water-soluble carbon source polyvinylpyrrolidone (PVP) and cost-effective electrospinning method. This work studied the impact of drying temperature on physical and electrochemical characteristics of the electrospun nickel phosphide nanofibers.

The Ni_2P/C nanofibers were synthesized via an electrospinning machine using PVP, nickel nitrate hexahydrate, and phosphoric acid as precursors. The nanofibers were spun at 18 kV voltage and 0.8 mL h^{-1} flow rate. The electrospinning humidity (RH) varied between 20-35%. Obtained nanofibers were dried at different temperatures between 110-130 ºC for 11 h. Finally, prepared fibers were annealed at 700 ºC for 1 h with a heating rate of 5 ºC min^{-1} in the N_2 + H_2 (4%) atmosphere.

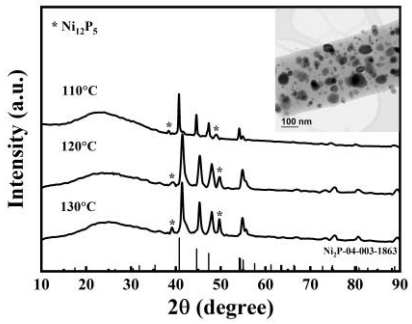

Figure 1. XRD patterns of nanofibers prepared at RH of 25% at different drying temperatures after heat treatment. İnset: TEM image.

The morphology and crystalline phases were observed using X-Ray diffraction (XRD, Miniflex, Rigaku). The microstructure was studied by transmission electron microscopy (TEM). According to the results, Figure 1, Ni_2P with a hexagonal structure and the space group of P62m and $Ni_{12}P_5$ with a tetragonal structure, space group of 87:I4/m were formed regardless of difference in process parameters. TEM results show that nanoparticles are uniformly distributed within the fibers.

The electrochemical characteristics of Ni_2P/C nanofibers were studied using coin-type cells (CR2032) with Li and polypropylene separator under Ar gas (99.9995% purity) in Glove box using 1 M $LiPF_6$ dissolved in a mixture of ethylene carbonate, diethyl carbonate, and ethyl methyl carbonate in 1:1:1 vol. ratio as electrolyte. Assembled cells were tested in a potential range of 0.01–3.0 V vs. Li/Li^+ at a current density of 100 mA g^{-1}. The current densities were calculated based on the mass of the samples which varied between 1.1-1.2 mg cm^{-2}. As a result, the highest initial charge capacity of 710.9 mAh g^{-1} with initial Coulombic efficiency of 61%, retaining a high capacity of 590.7 mAh g^{-1} after 100 cycles was achieved for the best sample.

Acknowledgements

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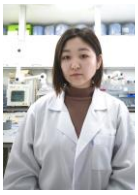

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