Enhancing Supercapacitor Performance with innovative doping: Electrochemical investigation of Phosphorus Supported MnO_2-Metal organic frameworks

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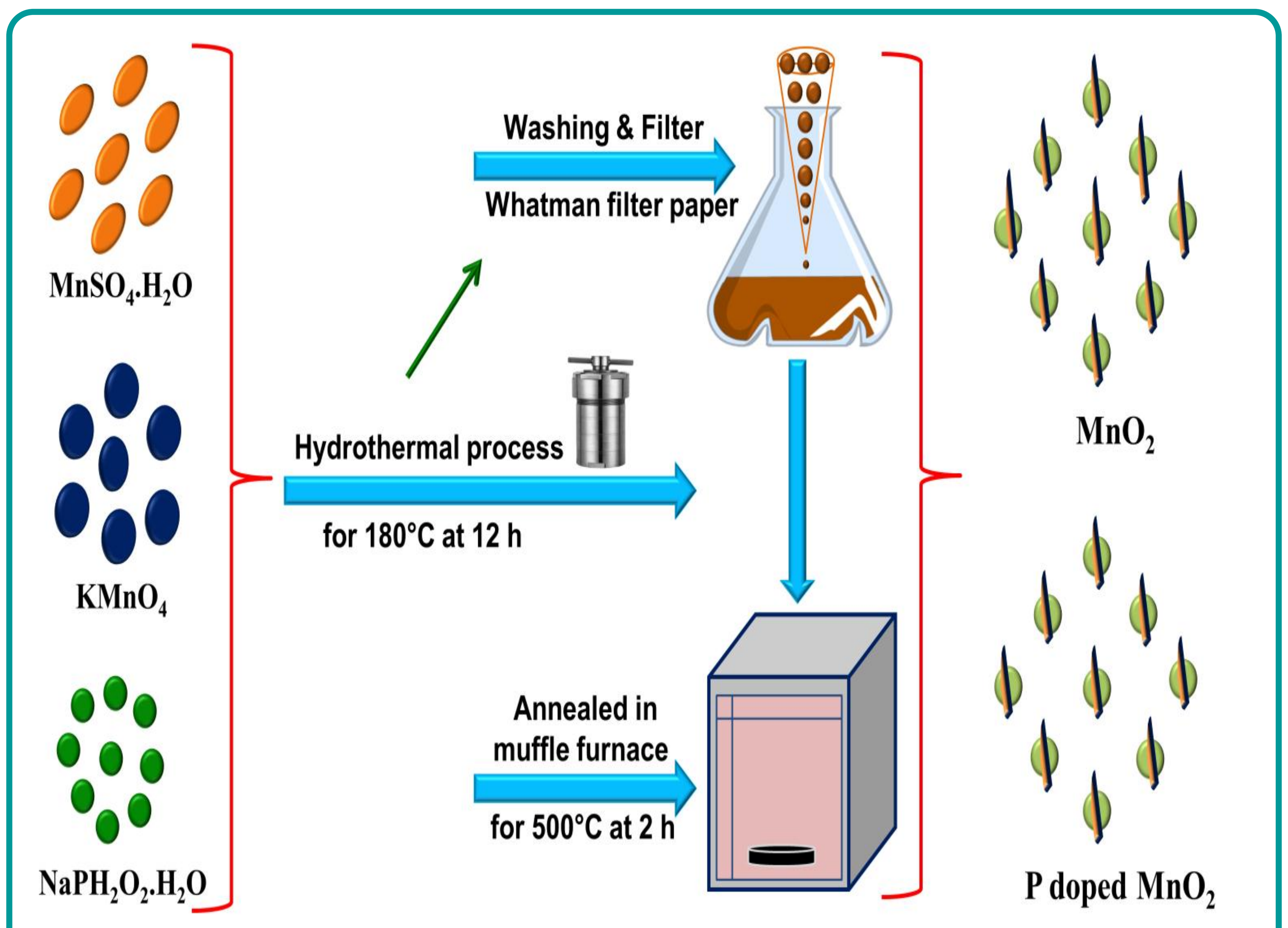
Abstract

Phosphorus and its compound species have made significant contributions to electrochemical performance. The hydrothermal approach was used to create pure and P-MnO_2 nanoparticles in this study. Phosphorus is uniformly distributed and makes good contact with MnO_2. The chemically binding and surfaces of the materials were investigated using XPS techniques. Mn2p, P2p, and O1s have high resolution spectra. The high-resolution Mn 2p spectrum shows the spin-orbit doublet states of Mn 2p3/2 and Mn 2p1/2, which correspond to two peaks at 639.8 eV and 651.8 eV. Phosphorus (P 2p1/2 and P 2p3/2) peaks at 130.1 and 131.0 eV. The MP 6 electrode material exhibits a high specific capacitance of 281.1067 Fg^{-1} at 0.5 Ag^{-1} current density and an excellent cyclic stability of 87.3% after 10000 charge-discharge (GCD) cycles at 6 Ag^{-1}.

Introduction

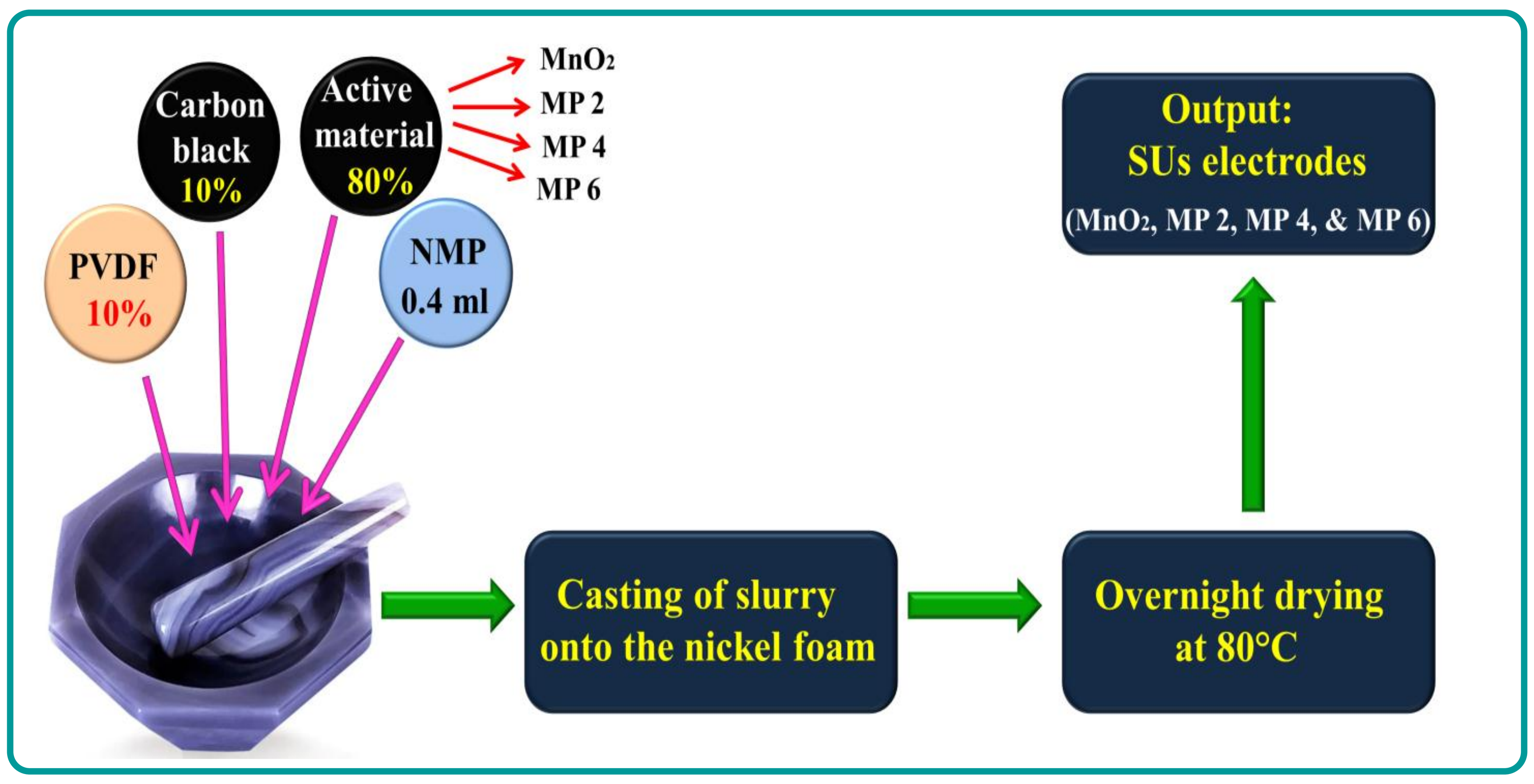
In today's world, electrochemical supercapacitors (ESs) are one of the most important energy storage technologies for a rising number of power portable electronics and electric cars. Supercapacitors are divided into two categories depending on their electrochemical storage features, such as double-layer electric capacitors and pseudocapacitors, with the former conserving energy between the electrode and electrolyte and the latter utilizing electro sorption of a surface via redox processes. The specific capacitance of electric double-layer capacitors (ion adsorption/desorption on high-surface-area carbon materials) is lower than that of pseudocapacitors (fast surface oxidation reactions of metal oxide)

Preparation of P doped MnO_2

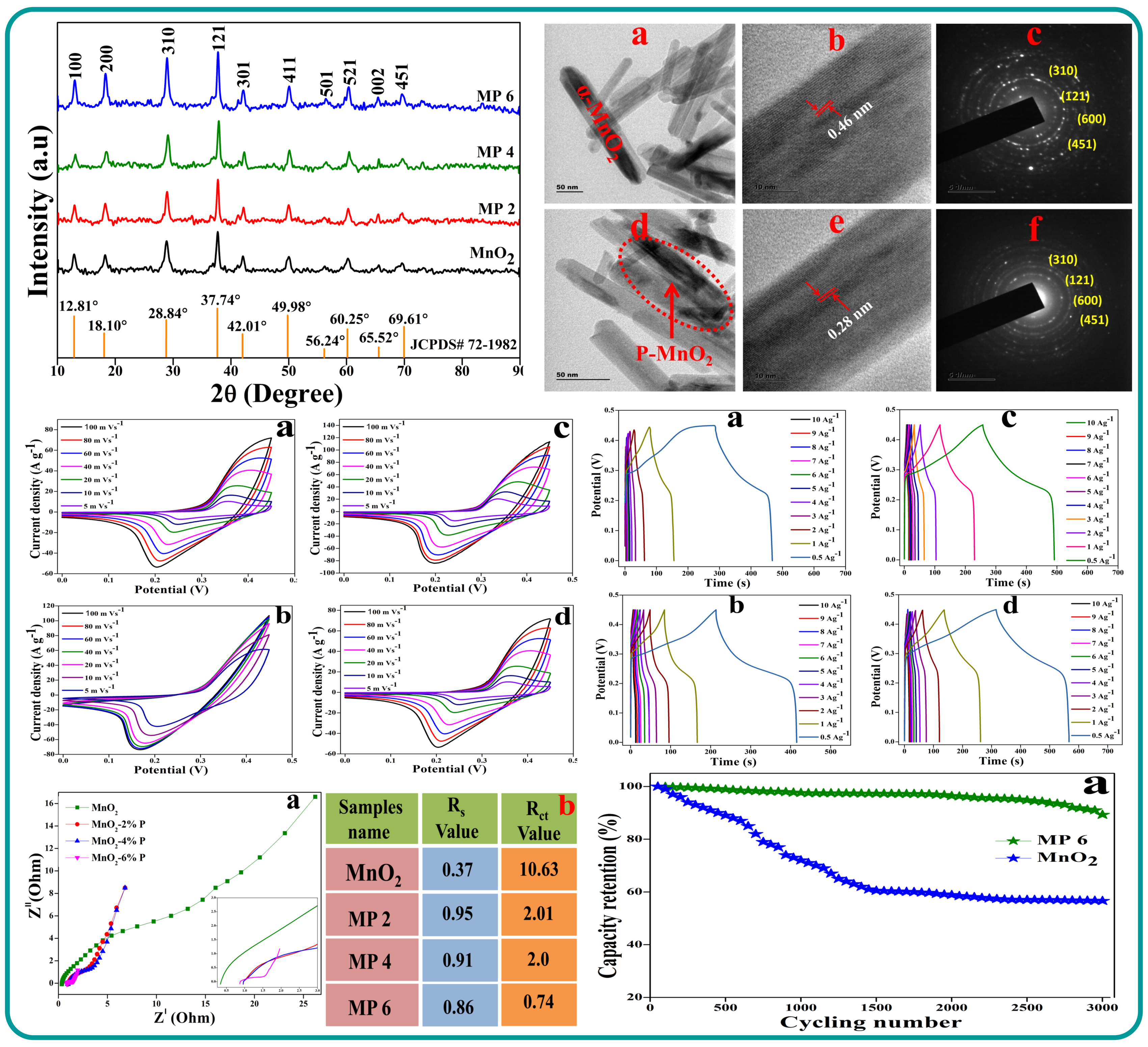


In this study, potassium permanganate ($KMnO_4$), manganese sulphate monohydrate ($MnSO_4.H_2O$), and sodium hypophosphite ($NaPH_2O_2.H_2O$) are utilized to create pure and P-MnO_2 nanoparticles. The autoclave was heated in an oven at 120°C for half a day. After that, the autoclave was allowed to cool to room temperature. To remove as much water and organic material as possible, the product was baked in an oven at 80° C until completely dry. Finally, the completed product was annealed in a muffle furnace at 500°C for 2 hours.

Fabrication of working electrode



Results



Samples name	R_s Value	R_{ct} Value
MnO_2	0.37	10.63
MP 2	0.95	2.01
MP 4	0.91	2.0
MP 6	0.86	0.74

Conclusions

The results of the XRD, FTIR, SEM, EDX, FESEM, TEM, BET, and XPS tests revealed that the as-synthesized α-MnO_2 tetragonal structure with nanorods has an excellent crystalline structure. The MP 6 (P-MnO_2) nanoparticle has electrochemical properties and a significantly increased specific capacitance ranging from 281.1067 Fg^{-1} with low solution internal resistance (0.86 Ω) and charges transfer resistance (0.74 Ω), as well as a remarkable cyclic stability of 87.3% after 10000 cycles at 6 Ag^{-1}.

References

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