

## Accepted Manuscript

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PII: S1385-8947(18)31812-6  
DOI: <https://doi.org/10.1016/j.cej.2018.09.095>  
Reference: CEJ 19934

To appear in: *Chemical Engineering Journal*

Received Date: 26 July 2018  
Revised Date: 1 September 2018  
Accepted Date: 12 September 2018

Please cite this article as: Q. Liu, X. Hong, X. Zhang, W. Wang, W. Guo, X. Liu, M. Ye, Hierarchically Structured  $\text{Co}_9\text{S}_8@\text{NiCo}_2\text{O}_4$  Nanobrushes for High-Performance Flexible Asymmetric Supercapacitors, *Chemical Engineering Journal* (2018), doi: <https://doi.org/10.1016/j.cej.2018.09.095>



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# Hierarchically Structured $\text{Co}_9\text{S}_8@\text{NiCo}_2\text{O}_4$ Nanobrushes for High-Performance Flexible Asymmetric Supercapacitors

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## Abstract

Hierarchically structured  $\text{Co}_9\text{S}_8@\text{NiCo}_2\text{O}_4$  nanobrushes constructed by  $\text{NiCo}_2\text{O}_4$  nanosheets grown on  $\text{Co}_9\text{S}_8$  hollow nanoneedles are first fabricated on carbon cloth substrates via a multi-step route. Remarkably, such  $\text{Co}_9\text{S}_8@\text{NiCo}_2\text{O}_4$  electrode processes multiplied electrochemical performance as compared to single  $\text{Co}_9\text{S}_8$  and  $\text{NiCo}_2\text{O}_4$  electrodes. It displays high-performance electrochemical behavior, achieving a specific capacitance of  $1966 \text{ F g}^{-1}$  at  $1 \text{ A g}^{-1}$  while maintaining excellent stability with about 92.9% capacitance retention after 5000 cycles. The flexible solid-state asymmetric supercapacitor based on this  $\text{Co}_9\text{S}_8@\text{NiCo}_2\text{O}_4$  electrode exhibits a high specific capacitance of over  $250 \text{ F g}^{-1}$  at  $1 \text{ A g}^{-1}$ , and delivers a high energy density of  $86 \text{ W h kg}^{-1}$  at  $792 \text{ W kg}^{-1}$  and a maximum specific power of  $11360 \text{ W kg}^{-1}$  at  $64 \text{ W h kg}^{-1}$ . Moreover, the supercapacitor holds more than 84.2% capacitance retention after 10000 cycles at  $10 \text{ A g}^{-1}$  and demonstrates good durability after different deformation, suggesting its outstanding cycle stability and flexibility. Thus, the  $\text{Co}_9\text{S}_8@\text{NiCo}_2\text{O}_4$  electrode with special heterogeneous structures shows the potential application in wearable energy storage devices.

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