

Nitrogen Configuration Enhances Electrochemical Capacity of Multifunctional Carbon Fibres in Structural Batteries

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INTRODUCTION: Carbon fibres can act simultaneously as reinforcement (traditional application) and electrode (novel application). This multifunctionality is used in so-called structural batteries [1] to create “mass-less” energy storage, where electrochemical energy is stored in load-carrying components. However, commercial carbon fibres are not designed for such multifunctionality. Still, two promising carbon fibre types are T800 and IMS65. These fibre types seem to be very similar in microstructure and composition, but they differ greatly in electrochemical capacity where IMS65 has the highest performance [2]. Here we identify a potential explanation for this difference.

METHODS: The relatively low levels of nitrogen (N) in carbon fibres require higher sensitivity and resolution than lab X-ray photoelectron spectroscopy (XPS) offers. Hence, we used synchrotron hard X-ray photoelectron spectroscopy (HAXPES). We employed the software MultitPak for signal deconvolution.

RESULTS: Analysis of the spectra reveal that N in T800 and IMS65 fibres configures in five chemical states: pyridinic-N at 398.5 eV, pyrrolic-N at 399.6 eV, graphitic-N at 401.0 eV, edge-located graphitic-N at 402.2, and oxidic-N at 403.8 eV. The amount of pyridinic- and pyrrolic-N is higher in IMS65 than T800.

DISCUSSION & CONCLUSIONS: Nitrogen configured as N1 and N2 creates defects in the graphene layers of the carbon fibre. These defects act as active sites for lithium ions to be inserted into [3]. Thus, a carbon fibre like IMS65 with a higher amount of N1 and N2 will have more active sites and higher electrochemical capacity. Here we have identified a currently unexploited design parameter for future carbon fibre manufacturing that can enhance the energy storing capability. With Synchrotron-based Hard X-ray Photoelectron Spectroscopy we find that pyridinic and pyrrolic configurations of nitrogen in carbon fibres increases electrochemical

capacity [4]. These findings pave the way for improved multifunctionality of carbon fibres and structural batteries.

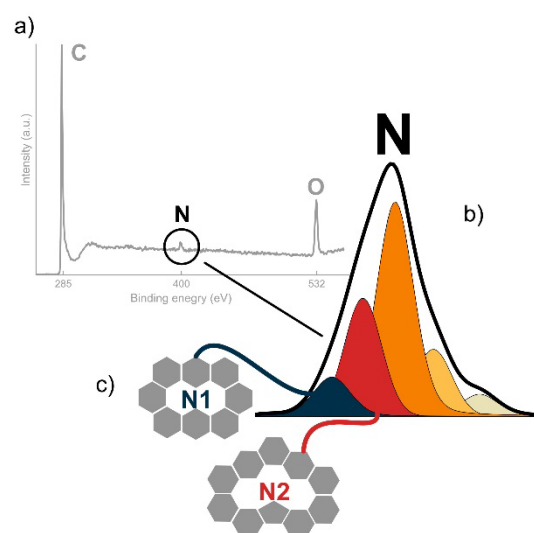


Fig. 1: a) HAXPES spectrum. b) Deconvolution of N signal. c) Schematic representation of pyridinic-N (N1) and pyrrolic-N (N2) in a graphene layer.

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