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Titania mixed with yttria used as both an additive in sulfurated polyacrylonitrile (SPAN) cathodes and as an interlayer between the cathode and the separator in Li-S batteries

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Introduction

Lithium–sulfur (Li–S) batteries are considered as the next-generation energy storage devices because of their high theoretical specific capacity and energy density of 1675 mAh g^{-1} and 2600 Wh kg^{-1}, respectively. A novel cathode material for Li-S batteries was studied. Herein, using a straightforward synthesis for SPAN and adding a small amount of TiO_2/4% Y_2O_3, we create a composite with very promising characteristics for being used as a cathode in Li-SPAN cells. Moreover, we use the same additive in order to create an interlayer between the cathode and separator.

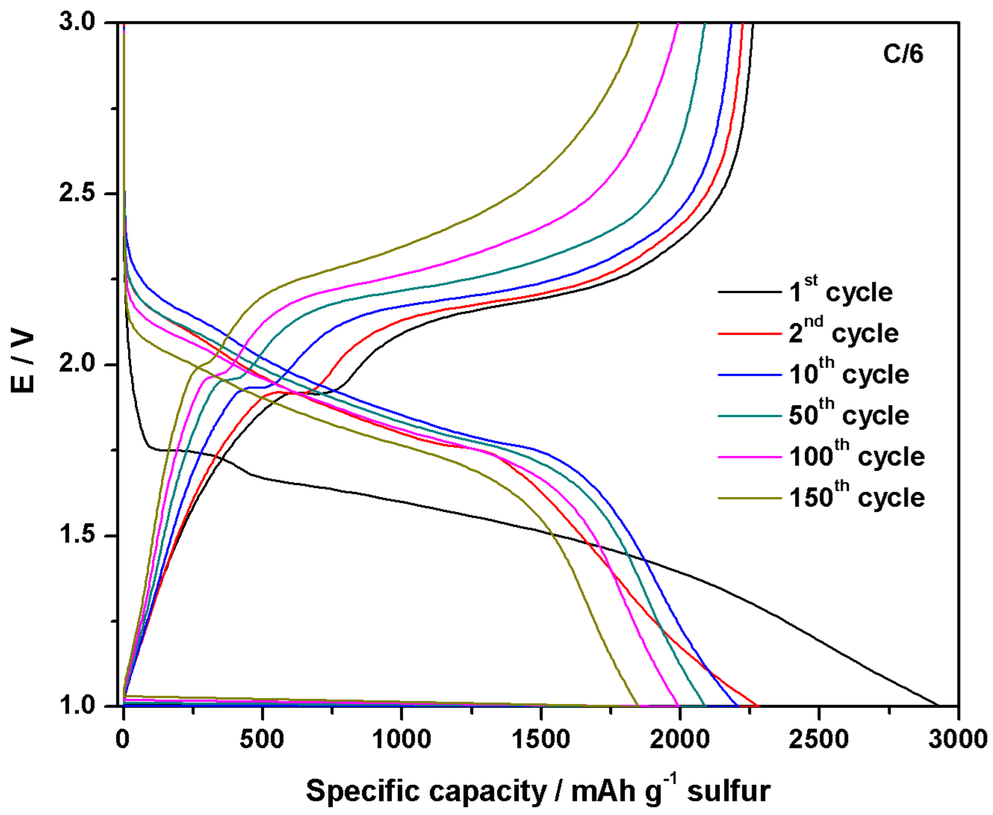
Methods

The novel composite was prepared by ball-milling elemental sulfur, polyacrylonitrile and TiO_2/4% Y_2O_3, followed by a heating treatment. The sulfur content determined by ICP-OES was 28.9 % S. The interlayer was prepared by mixing TiO_2/4% Y_2O_3 with carbon super P. Electrochemical tests were performed in a two electrode configuration, using coin-type cells (CR 2032) and in 1 M LiTFSI in EC:DMC:DEC as electrolyte.

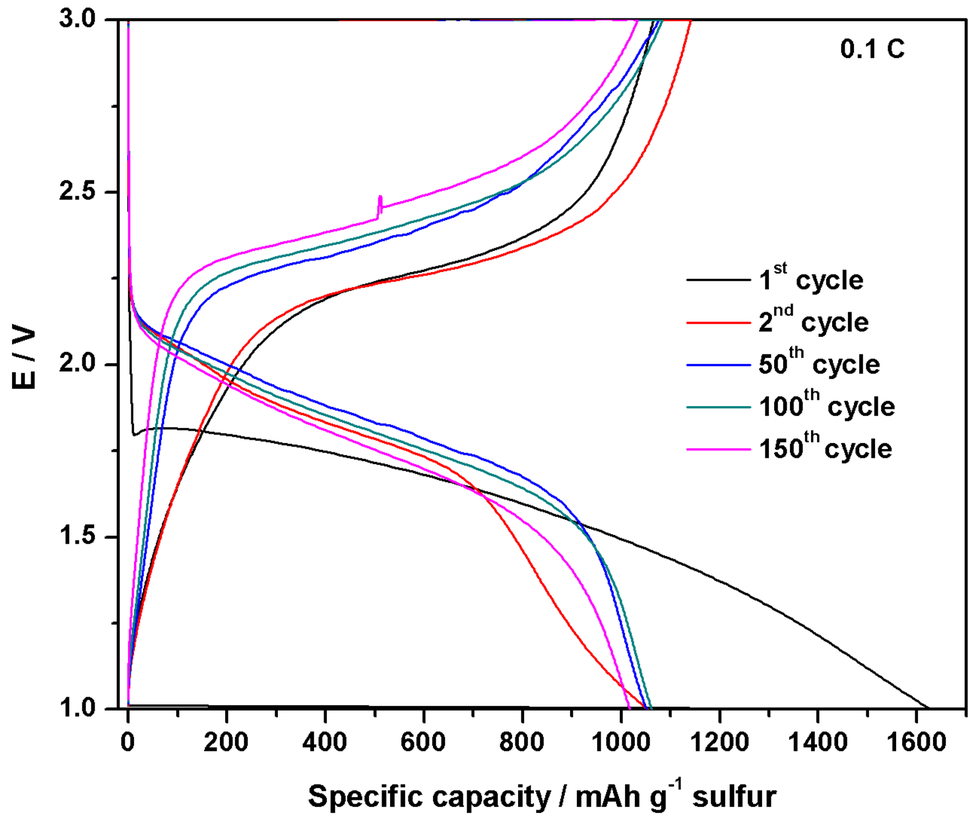
Results

The results obtained so far showed that the electrochemical behavior of the SPAN cathode with the addition of TiO_2/4% Y_2O_3 and the interlayer with the same additive, achieved capacity values of 2285 and 1670 mAh g^{-1} for the second cycle and after 250 cycles at C/6 (0.16C), respectively. Whereas the capacities obtained for a SPAN cathode without any additive were 1054 and 1000 mAh g^{-1} for the second cycle and after 150 cycles at 0.1 C. Moreover, the study of capacity values at increasing rates for the cells prepared with novel SPAN cathode with additive and interlayer showed very low capacity fading and exhibited high cycling stability at high C-rates for 200 cycles.

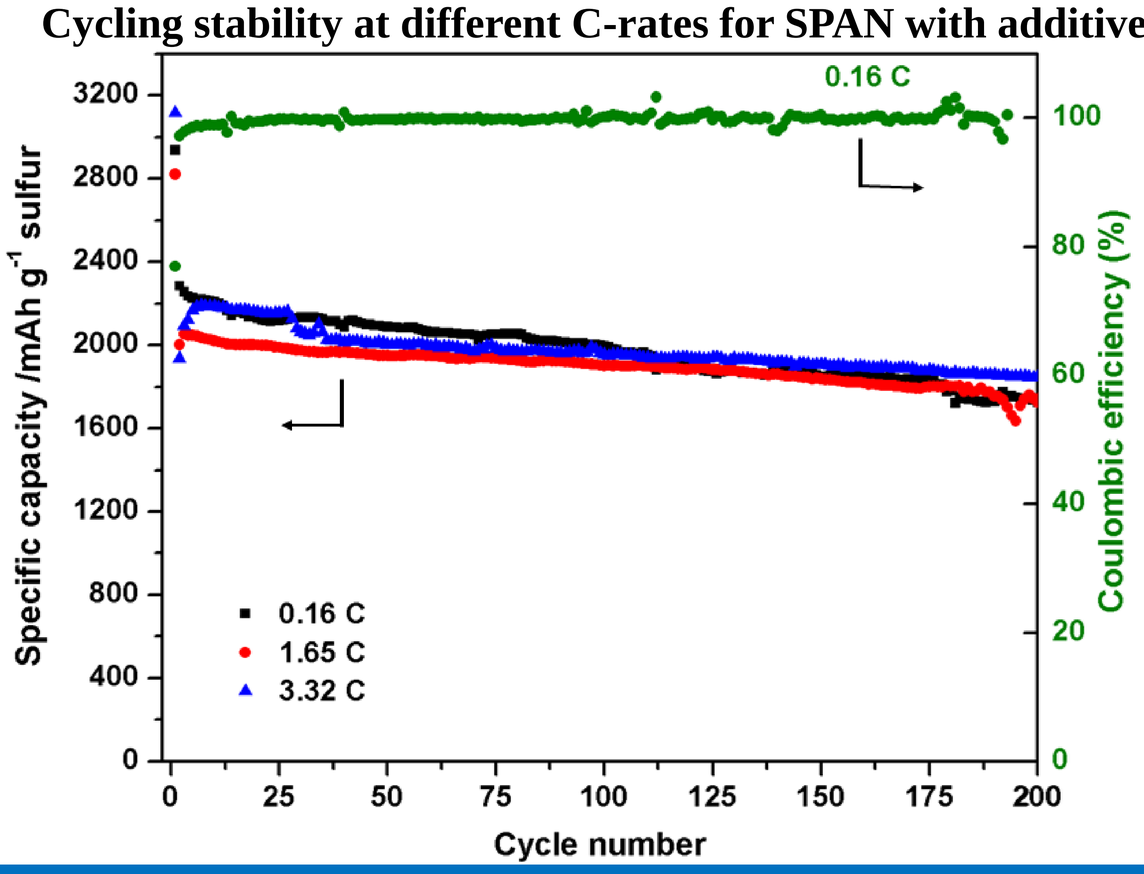
Discharge/charge voltage profiles for SPAN with additive



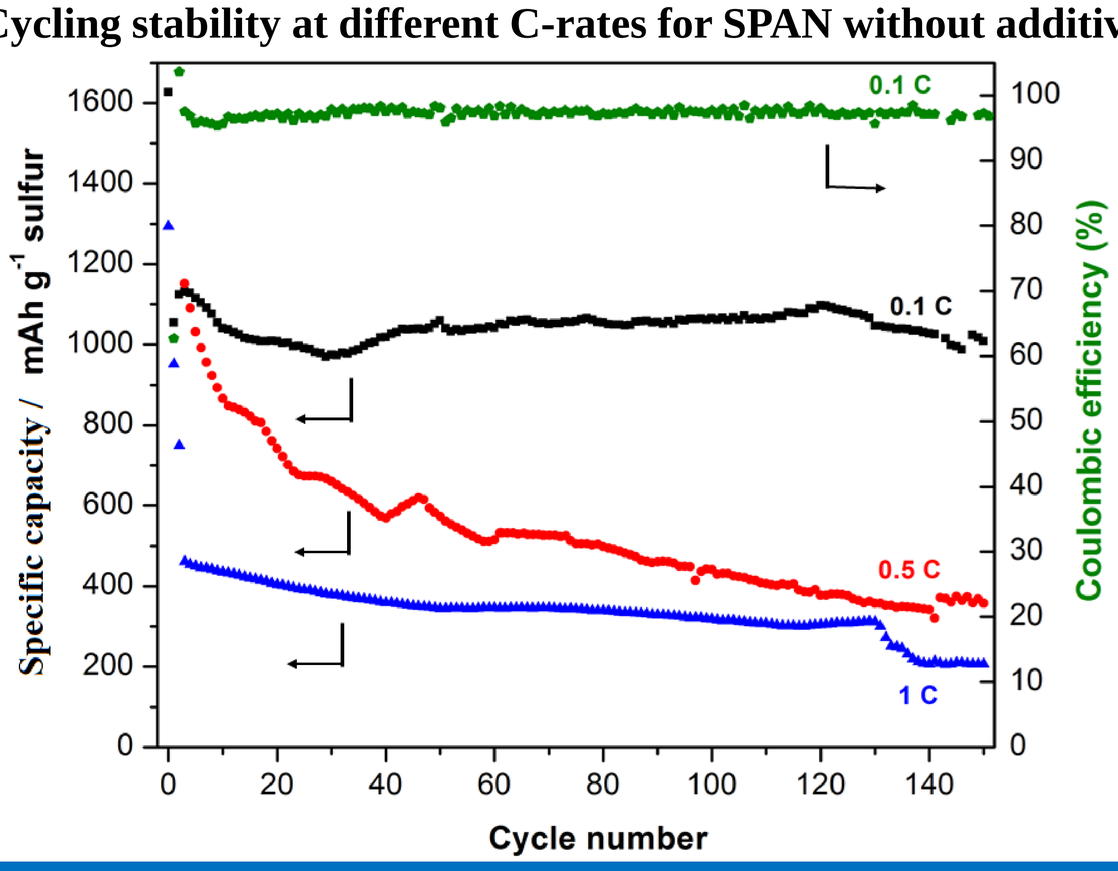
Discharge/charge voltage profiles for SPAN without additive



Cycling stability at different C-rates for SPAN with additive



Cycling stability at different C-rates for SPAN without additive



Conclusions

Comparing the SPAN cathodes with and without additive, we can conclude that there is a double positive effect of this additive when used both in cathode material and as an interlayer. Besides, we can assume that in our cathodes, the mechanism of the SPAN cathodes also involves the lithiation/delithiation of TiO_2, which could be providing extra capacity and this would explain the high capacity values observed in our cells, which are higher than the theoretical capacity of elemental sulfur (1675 mAh g^{-1}).

References

Páez Jerez, A. L. *et al. ChemistrySelect* **5**, 5465–5472 (2020).