Inkjet printed paper battery

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An alteration of the paradigm in the battery assembly can enable battery technology to seamlessly integrate into all size and shape-conditioned applications. Here, we show that a common inkjet printer can be used to dispense aqueous battery materials formulations [1], [2]. We used commercially available materials, focusing on lithium titanate (LTO)-based anodes and lithium iron phosphate (LFP)-based cathodes to exemplify the inkjet-printed paper battery concept, performances and feasibility.

Inkjet printed paper battery

Inkjet printing

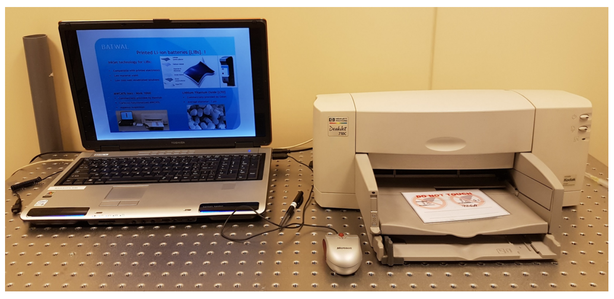
- well establish solution
- low-material waist
- allows the use of unconventional substrates
- low cost.

Paper

- high porous framework
- surface roughness
- enable lightweight and environmentally friendlier batteries
- can be used as separator.

Experimental setup

- HP DeskJet 710C
- HP45 rechargeable cartridge

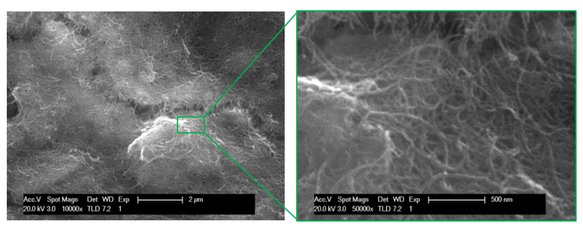


Printed current collectors

MWCNTs ink

- carboxyl modified MWCNTs
- commercially available

- Continuous and homogeneous MWCNTs deposits after 25 prints

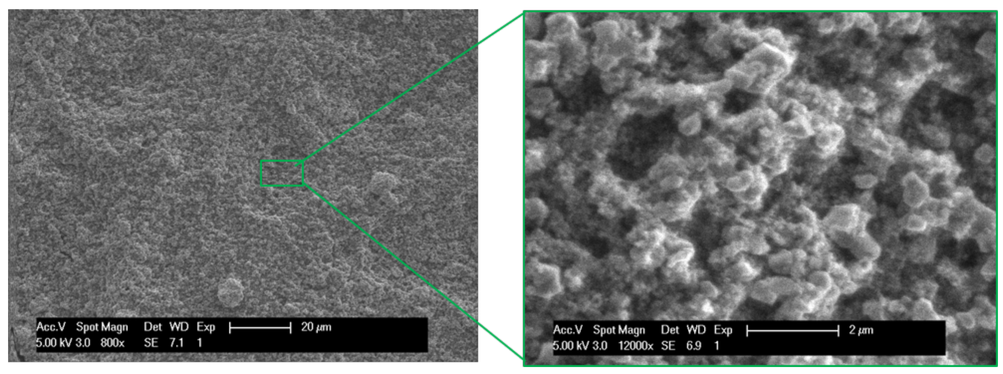


Printed anode

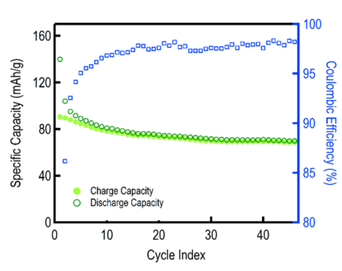
LTO

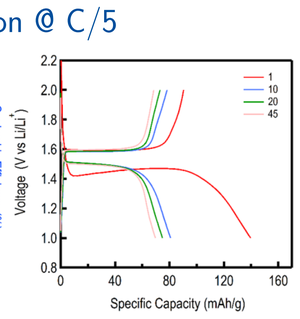
- specific capacity of 175 mAh/g
- Li^+ insertion potential 1.5 V vs. Li/Li^+
- exceptional cycling stability

- LTO deposit after 10 prints (0.8 mg/cm^2)

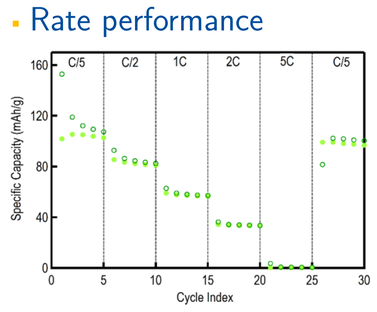


- Galvanostatic evaluation @ C/5





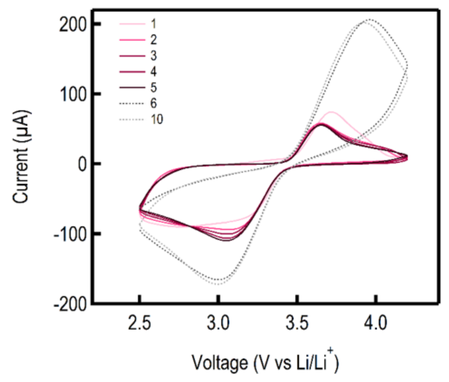
- Rate performance



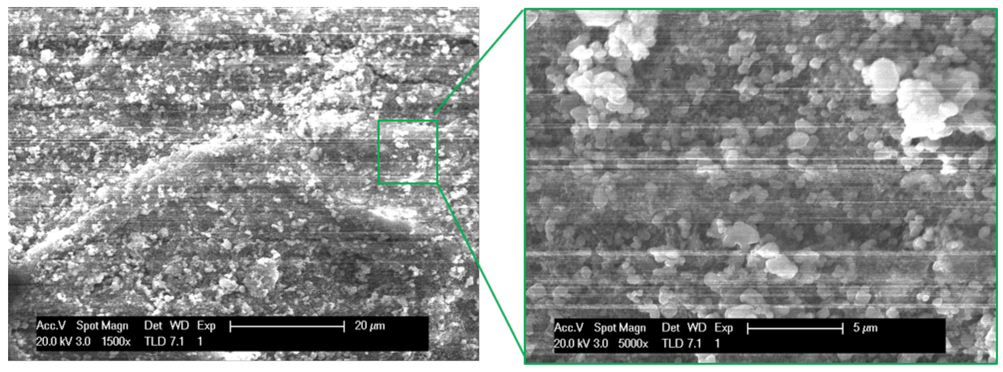
Printed cathode

LFP

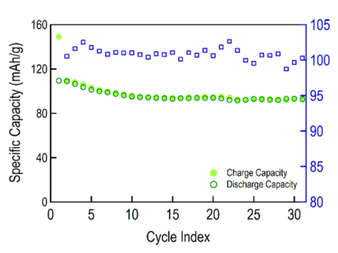
- specific capacity of 170 mAh/g
- Li^+ insertion potential 3.4 V vs. Li/Li^+
- environmentally friendlier

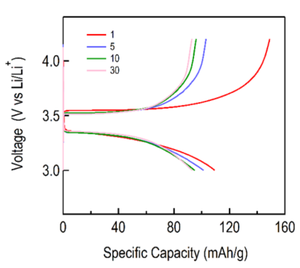


- LFP deposit after 7 prints (1.1 mg/cm^2)

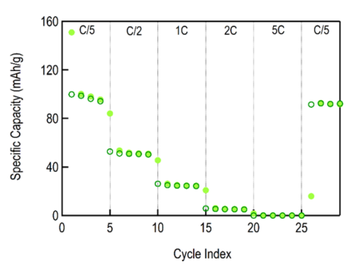


- Galvanostatic evaluation @ C/5



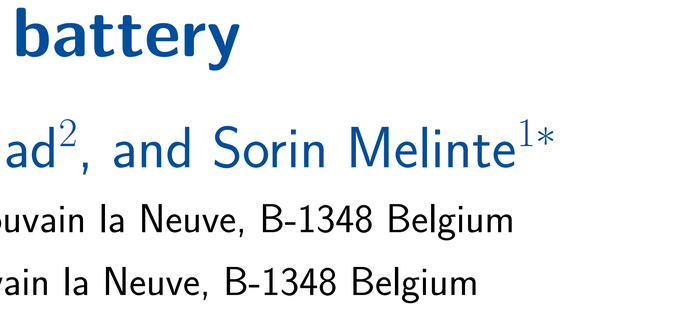


- Rate performance

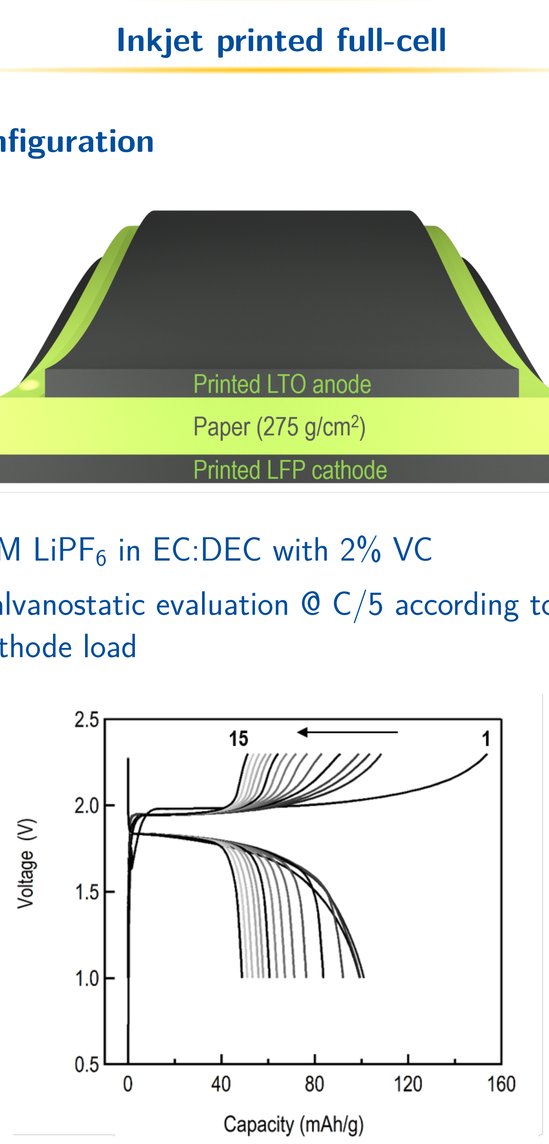


Inkjet printed full-cell

Configuration



- 1 M $LiPF_6$ in EC:DEC with 2% VC
- Galvanostatic evaluation @ C/5 according to the cathode load



Adopting inkjet printing for battery assembly responds to multiple types of applications from small scale (the common printer existing in any household) to industrial scale (roll-to-roll printers). The active materials can be engineered into aqueous paints, eliminating the commonly used volatile solvents like N-Methyl-2-pyrrolidone and their toxicity risks. Furthermore, paper can enable lightweight and environmentally friendly Li-ion batteries.

References

[1] Editors, *Nat. Nanotechnol.* **2017**, *12*, 283.

[2] N. Singh, C. Galande, A. Miranda, A. Mathkar, W. Gao, A. L. M. Reddy, A. Vlad, P. M. Ajayan, *Sci. Rep.* **2012**, *2*, 481.

Acknowledgements

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