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## ► To cite this version:

Marie-Eve Yvenat, Eric Mayousse, Benoit Chavillon. Solid Electrolyte Interphase in hybrid potassium-ion capacitor – A strategic materials-free and low-cost technology for high power applications. 75th Annual Meeting of the International Society of Electrochemistry, Aug 2024, Montréal, Canada. cea-04920058

**HAL Id: cea-04920058**

**<https://cea.hal.science/cea-04920058v1>**

Submitted on 29 Jan 2025

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# Solid Electrolyte Interphase in hybrid potassium-ion capacitor – A strategic materials-free and low-cost technology for high power applications

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In the framework of sustainable energy production and development, electrical energy storage (EES) is a key factor to achieve this goal. At the vanguard of energy storage are electrochemical storage based systems, such as batteries and electrochemical capacitors. For some years, a fine combination of batteries and electrical double-layer capacitors (EDLC) has been emerging as a way to offset the specific issues of both technologies and represent a new direction for future EES devices to reach high energy and power densities.

As a strategic materials-free and low-cost technology, the non-aqueous hybrid supercapacitor (KIC) represents a promising solution for high power applications. The KIC technology presented here consists of an activated carbon positive electrode and an oversized graphite negative one immersed in an acetonitrile based-non-aqueous electrolyte and a potassium salt [1]. The major obstacle to the development of this technology was the non-reproducibility of the results. In the case of Li-ion batteries, the formation protocol is known to be a key manufacturing step to create a stable and compact solid electrolyte interphase (SEI) on the negative electrode surface and ensure homogeneous and stable performance. This step has also been identified as being crucial for the KIC system. Thanks to the development of an adequate formation protocol [2], a homogeneous and continuous SEI with a low KF content can be created and performance at pouch cell scale are now stable and reproducible. Moreover, a correlation between the evolution of the KF content in the SEI and the evolution of cycling performance was observed. This results will be presented and discussed.

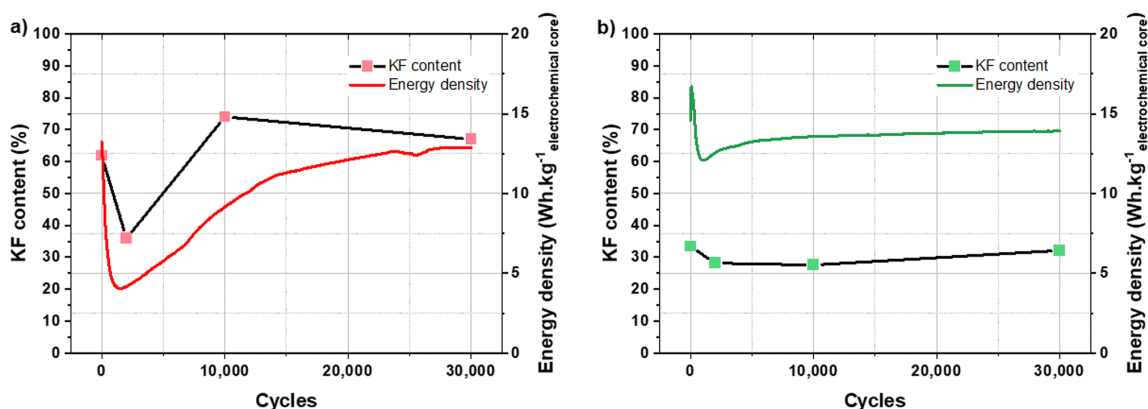


Figure 1: Evolution of KF content in the SEI and energy density of a KIC cell during cycling at  $16 \text{ mA cm}^{-2}$  at room temperature after initial formation (a) and developed formation (b)

These results are encouraging, however the cell format used may mask issues that will only become evident in a finished product (stacked or cylindrical prototype). In fact, pouch cells contain an excess of electrolyte and significant separator that allows an important supply of potassium ions. This is no longer the case in stacked or cylindrical prototypes. The objective is therefore to scale up the technology and to evaluate performance for real applications. Main results obtained at CEA on recent stacked prototypes will also be presented. The problems encountered during the scale up, the solutions developed as well as the performance obtained will be discussed in particular.

## References

- [1] Le Comte and al., Journal of Power Sources, Volume 363, 2017, 34-43, <https://doi.org/10.1016/j.jpowsour.2017.07.005>
- [2] Yvenat and al., Batteries, 2022, 8, 135, <https://doi.org/10.3390/batteries8100135>
- [3] Yvenat and al., Sustainable Energy Fuels, 2023,7, 4150-4159, <https://doi.org/10.1039/D3SE00594A>