Use of polyoxometalates-based nanomaterials for high energy density hybrid supercapacitors

Rosa Maria González-Gil, Jun-Jie Zhu; Pedro Gomez-Romero

Catalan Institute of Nanoscience and Nanotechnology (ICN2), CSIC and BIST, Campus UAB, Bellaterra, 08193 Barcelona, Spain.

rosamaria.gonzalez@icn2.cat ; pedro.gomez@icn2.cat

Supercapacitors, one electrochemical energy storage device (EES), have become fascinating devices due to their high power, low cost, long cycling performance and and fast charge/discharge rates. However, their energy density needs to be improved to compete with other ESS in the market, especially with batteries such Li-ion tecnologies.[1] The development of hybrid electrodes by means of combining different nanomaterials is one of the strategies to enhance the energy density of supercapacitors. In this sense, the properties of faradaic redox-active nanomaterials and purely double-layer capacitive nanocarbons are integrated into the same electrode.[2] Moreover, the combination in the same device one capacitive electrode and a faradaic one is another possible hybridization method to increase the performance, such as in the case of metal-ion supercapacitors (Li^+, Na^+, Zn^{2+}). Zn-ion is one of the chemistries that has increased its impact on the development of novel and greener energy storage devices, to zinc's low-cost, abundance and water compatibility and for this reason, has been considered as anode in hybrid devices.[3] Polyoxometalates (POMs) are well-suited redox-active nanomaterials (nanoscale metal oxide clusters from Mo, W, and V) that can perform fast reversible redox reactions without changing their structural stability,[4] providing an increase of capacity and cyclability when they are combined with nanocarbons such as activated carbon [2] or graphene oxide, [5] or inorganic 2D materials such as MXenes.[6] MXene materials has a very high volumetric capacitance, which combined with nanocarbons, which has high gravimetric capacitance, and POMs in a triple hybrid electrode shows better capacitance (87 F/g) with 1.5 times higher volumetric capacitance than those of Mxenes alone. [7]

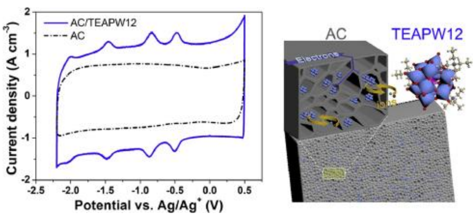

Figure 1: Left: CV from AC and AC/POM (TEAPW12) in acetonitrile showing an improvement on capacitance due to POM incorporation. Right: incorporation of POM in AC drawing.[2]

References

[1] Niraj Kumar, Su-Bin Kim, Seul-Yi Lee, Soo-Jin Park; Nanomaterials, 12, 20, (2022) 3708
[2] Jun-Jie Zhu, Raul Benages-Vilau, Pedro Gomez-Romero; Electrochimica Acta, 362 (2020) 137007
[3] Haiyan Wang, Wuquan Ye, Ying Yang, Yijun Zhong, Yong Hu; Nano Energy, 85, 2021, 105942
[4] Michael R. Horn, Amandeep Singh, Suaad Alomari, Sara Goberna-Ferrón, Raúl Benages-Vilau, Nilesh Chodankar, Nunzio Motta, Kostya (Ken) Ostrikov, Jennifer MacLeod, Prashant Sonar, Pedro Gomez-Romero, Deepak Dubal; Energy Environ. Sci., 14, 2021, 1652-1700
[5] Deepak P. Dubal, Nilesh R. Chodankar, Ajayan Vinu, Do-Heyoung Kim, Pedro Gomez-Romero; ChemSusChem, 10, 13, 2017, 2742-2750
[6] Jun-Jie Zhu , Pedro Gomez-Romero; Nanoscale, 14, 2022, 14921-14934
[7] Jun-Jie Zhu, Avireddy Hemesh, Jordi Jacas Biendicho, Luis Martinez-Soria, Daniel Rueda-Garcia, Joan Ramon Morante, Belen Ballesteros, Pedro Gomez-Romero, Journal of Colloid and Interface Science, 623, 2022, 947- 961.