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Rational design of graphene-based electrodes for energy storage systems

In 2014, the European Union listed 20 raw materials that were considered as critical to their economic stability [1]. Natural graphite was one of them, judged as having a higher economic importance and to be at a higher supply risk than cobalt, gallium or platinum, to name a few. While graphite can be made synthetically (at a much higher cost), natural mineral is the preferred raw material for a number of industrial applications including the production of electrodes for energy storage applications such as supercapacitors and batteries. With the advent of hybrid and electric vehicles, the demand for these systems (and natural graphite) is predicted to increase immensely in the next few years.

Given that graphite is a critical resource to Mankind (with other uses varying from lubricants to nuclear reactors), ensuring a supply-demand balance for this raw material will require a global effort to push forward the current carbon-based technology so that every gram is used to its maximum potential. In this respect, Nanocarbons have been recently explored as a possible step forward for the development of next-generation electrode materials of energy storage systems [2]. As the unit layer of graphite, graphene has a high specific surface area (2675 m2/g) which leads to a theoretical capacitance of 550 F/g, thereby setting an upper limit for all carbon-based electrode materials. Still, considering the low mass loading and its accessible surface area, the areal capacitance of single-layer graphene is limited to 21 μF/cm2, which renders its device application impractical. For this reason, much work has been carried out on reduced graphene oxide (rGO) to realize the mass production of graphene-based energy storage devices.

While there are numerous reports available which describe the supercapacitor performance of rGO-based supercapacitors [2], we found that a systematic study describing how different oxidation-reduction and drying strategies may influence the non-faradaic specific capacitance of these materials was missing. In the following, it will be explained how one can rationalize the various steps of chemical exfoliation of natural graphite to enhance the specific capacitance of rGO materials [3].

References

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