Stimuli-Responsive Micro-Supercapacitors Based on 2D Materials

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Abstract:
Smart micro-/nano-devices or stimuli-responsive devices, which can be engineered to respond to a variety of inputs, such as pH, ions, heat, light, magnetic field, etc., have attracted substantial attention due to a wide range of needs for smart modern electronics. However, it is still a great challenge to integrate various kinds of stimuli into modern functional devices without affecting the device performance, most probably due to the poor compatibility between stimuli, active materials and processing technologies. On-chip micro-supercapacitors (MSCs) are one kind of new-generation micro-sized power sources and have attracted considerable attention due to their small size, controllable patterning, in-plane feature and outstanding electrochemical performance. Unfortunately, stimulus-responsive micro-supercapacitors have not been reported to date.

We demonstrate the fabrication of the first stimulus-responsive and flexible MSC (SR-MSC) with a reversible electrochromic window. Taking advantage of the synergistic effect of one-dimensional (1D) V_2O_5 nanoribbons and two-dimensional (2D) exfoliated graphene (EG) nanosheets, EG/V_2O_5 hybrid nanopaper was prepared as electrode for MSCs, which delivered a high volumetric capacitance of 130.7 F cm^{-3} at 10 mV s^{-1} and high volumetric energy density of 20 mWh cm^{-3} at 0.75 W cm^{-3} with a polyvinyl alcohol (PVA)/LiCl gel electrolyte. These results are superior to most of graphene-based MSCs. Notably, as-prepared flexible SR-MSCs possess remarkable ultrafast response time down to 10 seconds, which provides a direct visual observation of the working state of MSCs. The progress for MSCs not only offering direct visualization of the energy storage state without the aid of extra techniques, but also making it possible for enhanced human-device interaction experience in the future. Beside this electrochromic MSCs, a few other stimuli-responsive MSCs developed by our group will be introduced.

References

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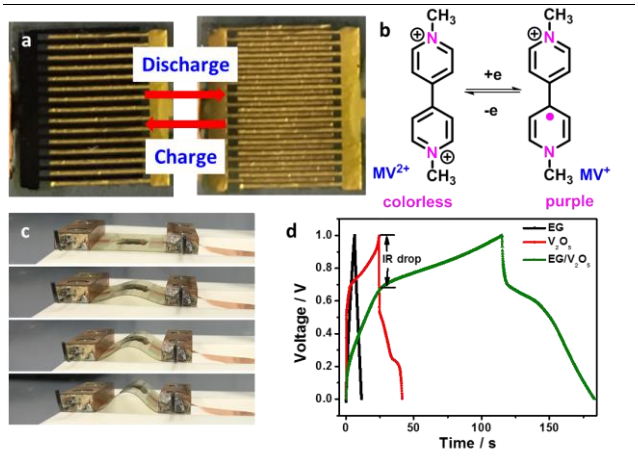

Figure 1: a) charge-discharge digital images of MSCs with viologenin electrolyte. b) Viologen-based electrochromic response mechanism. c) Flexibility and d) charge-discharge curves of SR-MSCs.