Graphitic carbon nitride nanosheet electrode-based high-performance ionic actuator

With the support by the National Natural Science Foundation of China and Ministry of Science and Technology of China, Prof. Chen Wei's laboratory from Suzhou Institute of Nano-tech and Nano-bionics, Chinese Academy of Sciences, reported the graphitic carbon nitride nanosheet electrode-based high-performance ionic actuator, which was published in *Nature Communications* (2015, 6: 7258).

Electrochemical actuators, which can convert electrical energy into mechanical energy have attracted great attention for a variety of biomimetic technologies ranging from robotics and microsensors to artificial muscle due to their impressive large strain under low voltage stimulation. Since their actuation performance is mainly dominated by electrochemical and electromechanical process of the electrode layer, the electrode material and structure become more crucial to higher performance. Carbon nanotubes and graphene have shown high specific surface areas and exceptional mechanical and electrical properties, making them prime candidates as actuation electrodes. However, the low electrochemical activity of carbon materials severely discourages their further improvement of the actuation response and strain levels. Therefore, a novel graphitic carbon nitride electrode where nitrogen active doping can not only increase the electrode's surface charge density but also enhance the interaction with ions, was introduced to desirably gain a high performance ionic actuator. The new actuator displays high electrochemical activity and electromechanical conversion abilities, including large specific capacitance (259.4 F g^{-1}) with ionic liquid as the electrolyte, fast actuation response (0.5±0.03% in 300 ms), large electromechanical strain (0.93±0.03%) and high actuation stability (100,000 cycles) under 3 V. The key to the high performance lies in the hierarchical pore structure with dominant size ~2 nm, optimal pyridinic nitrogen active sites (6.78%) and effective conductivity (382 S m^{-1}) of the electrode. This study provides a novel concept for the design of new hetero-atom modulating electrodes and also offers unprecedented access to next-generation electromechanical devices.

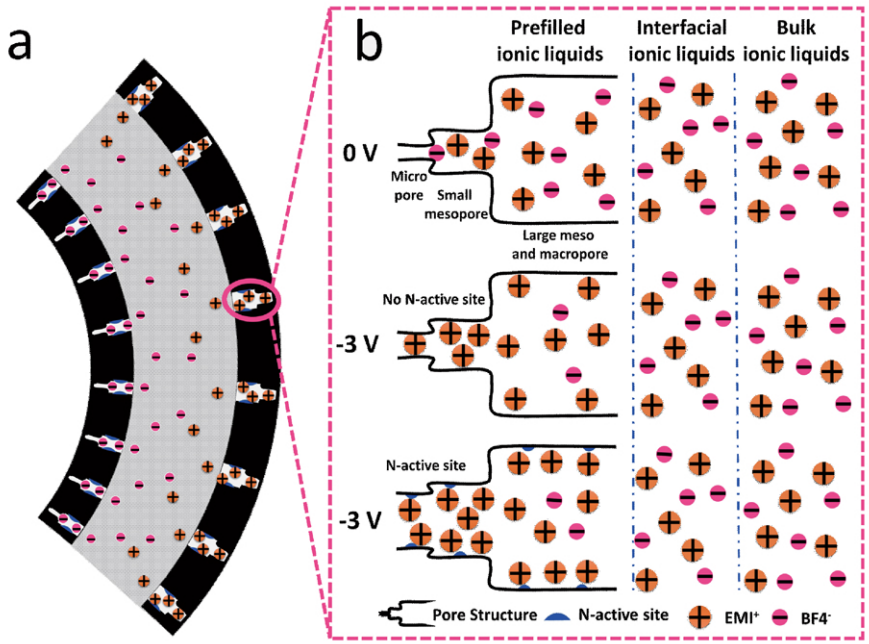

Figure Schematic illustration of the actuation mechanism. a, Bending motion of the graphitic carbon nitride electrode based actuator. b, Schematic illustration of the pore structure and cation-induced mechanical output of the actuators.