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Ionic Gating of Low Dimensional Materials as Inspiration for Future Hybrid Organic-Inorganic Bioelectronic Systems

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Traditional organic semiconductors developed as an analogous materials system next to inorganic semiconductors and were primarily investigated from the standpoint of electronic charge transport. More recently, advancements in the understanding of organic semiconductors have expanded the materials system into the growing field of organic bioelectronics, where the inherent advantages of high ionic transport and conductivity in organic polymers are better realized, allowing one to interface with and mimic the dual ionic-electronic conduction of biological systems.[1] On the other hand, while the poor ionic transport of bulk crystalline inorganics makes them ill-suited for bioelectronics, the continued discoveries of low-dimensional inorganic sheets, tubes, and dots provide crystalline structures that are ionically sensitive with unique optical, electronic, and thermal properties. Assuming inorganic-organic interfacial stability, one can imagine future hybrid bioelectronic systems that utilize ionically accessible low-dimensional materials to provide beyond-organic properties.

In this presentation, I will highlight work in the ionic gating of various low dimensional materials. I will discuss work in ionically gated carbon nanotube bundles as energy harvesters in artificial muscles (Fig. 1A).[2] and charge collectors in organic PV.[3] I will also discuss my doctoral work in ionic gating of molybdenum ditelluride as a reversible phase change element for electrochemical random access memory (Fig. 1B).[4] While the fields of bioelectronics and low-dimensional materials are in their infancy, the integration of low-D materials could provide alternative avenues to energy harvesting, memory, chiral-specificity, ionic transport, and localized catalytic properties that are seen in the functions of advanced biological material architectures such as proteins and enzymes.

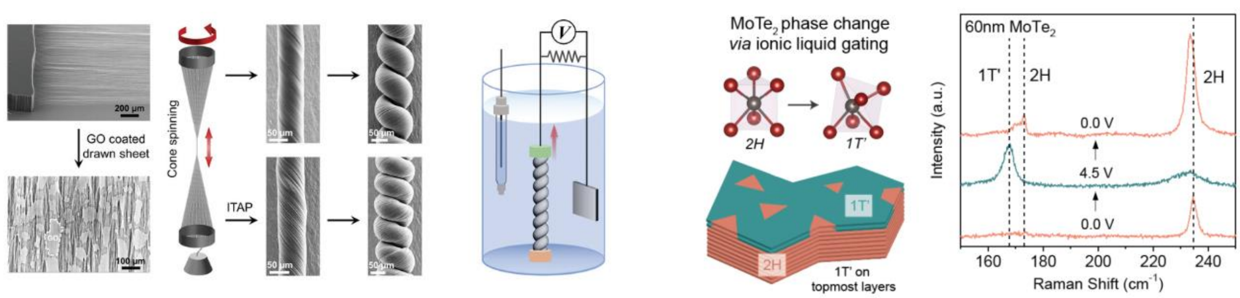

Figure 1. A) Carbon yarn made from spun carbon nanotubes for ionically gated muscle-like expansion and contraction **B)** Crystallographic phase change between the 2H and 1T' phases of $MoTe_2$ 2D flakes under ionic gating, as evidenced by Raman spectroscopy.

References

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