

# **ELECTRONIC PROPERTIES OF ORGANIC SINGLE CRYSTALS AND TWO-DIMENSIONAL HYBRID MATERIALS**

## **ABSTRACT**

Developing the next generation soft optoelectronic materials is of great importance for achieving high-performance, low-cost electronics. These novel material systems bring about new chemistry, physical phenomena, and exciting properties. Organic inorganic hybrid two-dimensional perovskites and organic stable radical molecules are two exciting material systems that bear high expectation and await extensive exploration.

Organic inorganic hybrid two-dimensional perovskites are considered one of the solutions to the pressing instability issue of halide perovskites toward commercialization. Moreover, dimension reduction of perovskites creates new opportunities for using two-dimensional perovskites as thermoelectric applications due to the ultralow thermal conductivity. However, two-dimensional perovskite thermoelectric is still at its' incipient stage of development, therefore a timely proof of potential is required to draw further research interests.

In earlier part of this work, the two-dimensional perovskites featuring  $\pi$ -conjugated ligands are synthesized and optimized for high thermoelectric performance. With material design, device engineering, intensive measurements, and careful data analysis, we successfully showed that two-dimensional perovskites are competitive candidate for the emerging thermoelectric materials. Furthermore, temperature and carrier concentration dependencies on thermoelectric properties were also established, giving future researchers a generalized optimization strategy.

Organic stable radical molecules are promising for organic electronics as stable radicals don't require high conjugation for efficient solids-state charge transport. Thanks to their unique redox capability and the unpaired electrons, organic radicals have many unique electronic and magnetic properties that could be useful in spin-related applications. However, the understanding in charge transport mechanisms as well as structure-to-properties correlation remain shallow.

In later part of this work, we achieved the highest recorded long channel electrical conductivity of non-conjugated radicals. Meanwhile, the important role of close packing between radical sites was demonstrated by slightly changing chemical design that resulted in drastic change

in electrical conductivity. Finally, we concluded that the solid-state charge transport in non-conjugated species is governed by variable range hopping mechanisms.