Cold Thoughts on Perovskite Fever

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The latest progress in solution-process-based organic-inorganic hybrid perovskite solar cells is reshaping the growth pattern of any previous photovoltaic technologies and has raised a storm of research fever. However, despite the success in boosting efficiency, it also appears high time to inject an intense dose of cold thoughts into this globally-spreading “perovskite fever”, because perovskite solar cells are still facing several critical challenges. For example, these hybrid perovskites suffer from the materials instability in moisture, the use of environment-hazardous lead, the costly and unstable complex organics as hole transport materials, the use of precious metals as back cathode, the hysteresis in current-voltage scans, the tricky engineering of good-quality perovskite films. Moreover, there are still some missing puzzle pieces for a comprehensive basic science understanding of the extraordinary excellence in both charge transport and light harvesting in hybrid perovskite materials so as to provide crucial fundamental clues that can navigate future research towards the approach of better photovoltaic materials by designing. In this talk, I will present some of our work on tackling these challenges. First, I will show that nickel, as an industrial commodity metal with work function of 5.1 eV, can replace gold as the back cathode in perovskite solar cells with competitive performance to gold-cathoded cells, and the work function and the conductivity of the cathode are both fundamentally important factors impacting the photovoltage and fill factor of the perovskite solar cells. Furthermore, I will also show that when partial iodides in CH$_3$NH$_3$PbI$_3$ are replaced with pseudohalide ions thiocyanate (SCN$^-$), the resulting SCN-containing perovskite films strikingly rival the conventional CH$_3$NH$_3$PbI$_3$ films in terms of moisture-tolerance as evidenced by their tolerance in 95% relative humidity in air for over 4 hours without significant degradation, in contrast to pristine CH$_3$NH$_3$PbI$_3$ films that degraded in less than 1.5 hours. The solar cells based on the SCN-containing perovskite thin films exhibit efficiency comparable to that of CH$_3$NH$_3$PbI$_3$-based cells fabricated in the same way. In this talk, I will also present our recent discovery of a new kind of electron-lattice interaction in semiconductors, namely electron-rotor interaction discovered in hybrid perovskite materials using isotope effects and the unusual optical and electronic properties of perovskite materials under high pressure condition.

To be presented at Department of Chemistry, The University of South Florida