Long-range coherent charge transport in physisorbed molecules

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The charge transport in molecular ensembles is intrinsically related to a series of carrier-molecule quantum interactions, resulting in embracing chemical and biological phenomena. Its understanding has paved the way to the development of novel device concepts, such as organic transistors, organic light-emitting diodes, and biosensors. At the nanoscale, such interactions are commonly described as either direct tunneling (DT) for the 1-10 nm range, and activated hopping for longer distances. However, the continuous transition between DT and hopping as a function of the barrier width remains unknown for the wide range of physisorbed molecules. This work describes the first experimental evidence of long-range (> 10 nm) coherent tunneling occurring in physisorbed molecular ensembles. By investigating the charge transport in copper-phthalocyanine (CuPc) thin films, we have identified the sequential tunneling (ST) as the long-range charge transport mechanism. The ST is an activationless, multi-step process intrinsically distinct from both the DT and the hopping conduction. As a consequence, gradual transitions from DT to ST and from ST to hopping could be verified at low temperatures as a function of the barrier width (film thickness). The evidence of coherent charge transport (ST) across long distances (> 10 nm) has implications for a variety of quantum effects never previously verified for molecular pathways longer than a few nanometers. Therefore, our results [1] contribute to bridge the gap between molecular and organic electronics for the elementary set of physisorbed molecules.

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References:

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