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FOR BASIC SCIENCES
Block JD, Sector III, Salt Lake, Kolkata 700 106

DEPARTMENTAL SEMINAR

Condensed Matter and Materials Physics

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SPEAKER
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TITLE OF THE TALK

Protein as a Strange Conducting Medium with a Unique Electron Transport Capability

ABSTRACT

Proteins are fascinating candidates for bio-molecular electronics because of their diverse properties and functions. In biology, redox proteins show fast, directional electron transfer (ET) over several nm (in ~1 nm steps) in membranes and cytoplasm. Solid-state electron transport (ETp) has been observed by immobilizing proteins on and between electronically conducting electrodes as mono- and multi-layer protein assemblies. Such bio-compatible ultrathin protein films show highly unusual, relatively efficient electronic conduction, comparable to or higher than conjugated organic molecules, that is weakly or not at all temperature- or length-dependent.1 Our recent results of near activation-less ETp through the bacteriorhodopsin multilayers pose challenging questions on the transport mechanism.2 The unique weak length-dependent conduction of protein junctions adds a new aspect to be accounted for in the mechanism. It might be related to the quantum Child-Langmuir law and suggests a ballistic type of transport. In my lecture, I will show the results with solid-state protein junctions, differing in electrode nature and configuration, for several proteins, both with and without electron-rich cofactors.3 Different protein junctions show near-temperature independence transport over lengths scale well above any possible quantum tunneling limit, with weak length and voltage dependence. The experimental results are consistent with the voltage dropping mainly across the protein electrode.2,3 At the same time, transport through /within the protein(s) is relatively facile, especially with increasing film thickness. Impedance results confirm the absence of shorts in the junction between the top and bottom electrodes. Moreover, no significant charge distribution/surface potential variation was observed with an increasing number of protein layers. We estimate electrode Fermi level to frontier orbital energy differences of at least ~1 eV.2 Hence, no protein-energy levels are available for resonance transport, especially near 0 V applied bias (few 10s mV) where the junction behaves ohmic. Unique electrostatics and particular distribution of positive and negative ions inside the protein matrix could allow such efficient transport over 30-60 nm lengths. Control experiments with thicker polymer layers provide exciting findings. The currents through poly-ionic polymers are comparable/more efficient than dry proteins. 3 With a neutral polymer (PMMA) no current is measurable over 30 nm.2 Elucidating the transport mechanism is especially important as it may well bear on the amazing behaviour of the cm-length cable bacteria. 4

References
1. Amdursky et al. Adv. Mater. 2014, 26 (42), 7142–7161.
2. Bera et al. J. Am. Chem. Soc. 2023, 145 (45), 24820–24835.
3. Bera et al. (to be submitted)
4. Reguera et al. Nature 2012, 491 (7423), 201–202.

HOST FACULTY

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