Incoherent electron transport in single porphyrin molecular junctions

About the Project

The group’s interests lie at the interface between chemistry and physics. In the molecular electronic laboratory, we focus on a deeper understanding of electron transport at the nanoscale. We use cutting edge scanning-tunneling-microscopy techniques to ‘wire-up’ individual molecules and measure their transport properties. We are particularly interested in studying all aspects of nanoscale transport involving individual molecules, from understanding how molecules bind to metal electrodes to investigating transport mechanisms and specific phenomena such as quantum interference. Porphyrins hold particular interest for us; they are important biological molecules with highly interesting chemical properties suited to nanoscale electronics.

Over recent years, we have studied the single molecule conductance behaviour of porphyrin wires as a function of the number of individual porphyrin units (i.e. the molecular length) and found that the transport properties depend strongly on how the units are coupled. For the most strongly coupled systems, we discovered many interesting effects, such as increasing conductance with length (which occurs above a certain bias voltage). We observed transient charging of individual molecules, in which single molecules either become oxidised or reduced (loss or gain of an electron). The project will investigate this further as it might open the door to a whole host of possibilities. We envisage that discrete charging of a molecular wire could be extremely useful in future applications ranging from molecular memristors to molecular thermoelectronic devices. Little is known about the details of the charging process, and questions such as how many electrons are involved remain open. We would like to take our understanding of this nanoscale electron transport process to the next level. Current-voltage spectroscopy, thermopower and also investigations using an electrochemical gate will help to build a complete picture of how the process works.

The position is open to candidates with a background in Chemistry, Materials Science or Physics. Open minded applicants, with a passion for novel chemistry and physical phenomena at the nanoscale, and a curiosity for advanced instrumentation are highly welcome. The applicant will
oversee the running of scanning tunnelling-microscope equipped with temperature control to perform thermopower measurements as well as an electrochemical cell to carry out measurements under potential control. Further modifications are planned, and the successful candidate will contribute in developing the instrumentation, such as with the addition of magnets.

The candidate will manipulate long porphyrin tapes, similar to graphene nanoribbons, up to 10 nm in length, and study their properties (conductance, voltage dependence, electrochemical response and thermopower). New structures can be synthesized according to the results.

This project offers a unique chance to work at the frontier between chemistry and physics attaining a broad range of skills for their future professional development. They will develop a deep understanding of how physical properties relate to molecular structure, how to manipulate matter at the atomic level to achieve desirable effects and gain experience controlling state-of-the-art equipment.

The candidate will take part in regular meetings with our collaborators Harry Anderson (University of Oxford), Richard Nichols (University of Liverpool), Birgit Esser (University of Freiberg) and Linda Zotti (Universidad Autónoma de Madrid). Secondments are planned at any of the institutes of our collaborators.

https://www.nanociencia.imdea.org/molecular-electronics-laboratory/group-home

**How to apply**

This is a competitive fellowship opportunity, funded through “la Caixa” INPhINIT programme. Interested candidates should get in contact (edmund.leary@imdea.org) for an informal discussion about the project and how we can support your application.

**About IMDEA Nanociencia**

IMDEA Nanociencia is an interdisciplinary research centre dedicated to the exploration of basic nanoscience and the development of applications of nanotechnology in connection with innovative industries. Our purpose-built building was inaugurated in 2014 and the institute has since been consecutively awarded with the highest national recognition of scientific excellence and international impact. The institute has a high scientific output >2,000 indexed publications (~200 per year, >80% in Q1 journals) and counts with state-of-the-art facilities in over 40 operative laboratories.

We are located at the UAM-CSIC Cantoblanco Campus, just a few minutes away from Madrid's lively city centre, connected by “cercanías” trains and several bus lines. We are fully committed to equality and diversity in the workplace and we encourage applications from all candidates irrespective of their background.