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Benzene: the Molecule that Changed the World

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Abstract:
Transparent organic-inorganic nanoporous silica The origin of complex nanomaterials such as graphene is formally based on the discovery and understanding of benzene, the fundamental aromatic compound, whose unique and enigmatic structure posed a challenge for chemists of the time. Michael Faraday is credited with the discovery of benzene in 1825, just 200 years ago, when he fractionated the "fluid obtained during the compression of oil gas."[1] Initially, Faraday referred to this substance as "bicarburet of hydrogen." Its actual empirical formula, C_6H_6, was determined nine years later. The remarkable stability of benzene defied the typical expectations of unsaturated hydrocarbons until its structure was finally determined by August Kekulé in 1865 and confirmed via X-ray diffraction by Kathleen Lonsdale in 1925.
This presentation delves into the pivotal years surrounding the discovery and structural elucidation of benzene, followed by the captivating architectures of its current molecular successors, culminating in graphene,[2] a material that has been poetically described as a gift from the gods.[3]

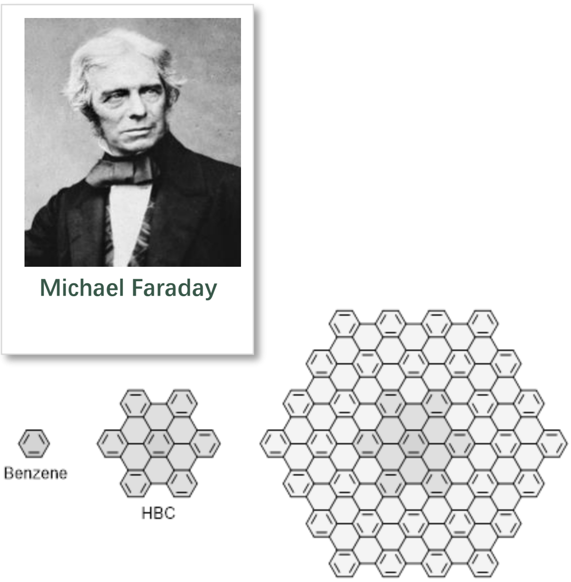

Figure 1: Figure showing the photo of Michael Faraday, Discoverer of Benzene in 1825 and its evolution to Graphene.

Keywords: benzene, carbon nanostructures, graphene, 2D materials, on-surface synthesis,

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Acknowledgements
Financial support from the Spanish MICINN (Project PID2023-146373OB-I00)

Development of Advanced Magnetic Microwires with Amorphous Structure for Technological Applications

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Abstract:
Amorphous magnetic wires have attracted great attention owing to their superior soft magnetic, mechanical and corrosion properties. Excellent magnetic properties such as fast magnetization switching related to magnetic bistability or Giant Magnetoimpedance (GMI) effect are suitable for magnetic sensors applications [1]. Recent tendency in devices miniaturization stimulated development of thin (few µm diameters) microwires [1]. So-called Taylor-Ulitovsky technique allows preparation of amorphous microwires with thin metallic nucleus (typically with diameters 0.2 to 100 µm) covered by flexible, insulating and biocompatible glass. The unique properties of such microwires make them suitable for various applications [2]. Better magnetic softness and higher GMI ratio, ΔZ/Z, have been reported in Co-rich amorphous microwires, while Fe-rich amorphous microwires exhibit spontaneous magnetic bistability related to remagnetization process through fast domain wall propagation [2]. Less expensive Fe-rich microwires are preferable for the applications. However, amorphous as-prepared Fe-rich materials exhibit rather high magnetostriction coefficient and consequently present quite low GMI effect. Accordingly, we focused on designing the post- processing allowing further optimization of magnetic properties of Fe- and Fe-Co based glass-coated microwires [2]. Conventional annealing allows considerable improvement of domain wall dynamics in Fe-rich microwires and slight decrease of coercivity, however remarkable magnetic hardening is observed after conventional furnace annealing of Co-rich microwires. Stress annealing of Fe-rich microwires allows considerable magnetic softening and GMI effect enhancement (Figure 1) and even more remarkable improvement of domain wall dynamics. In Co-rich microwires stress-annealing allows improvement of GMI effect and even induction of transverse magnetic anisotropy at high enough annealing temperature. The highest GMI effect is observed for stress-annealed Co-rich microwires which present linear hysteresis loops with low coercivity. In properly annealed Co-rich microwires a coercivity of about 2 A/m has been obtained [2]. Consequently, annealed Co-rich microwires can present both fast domain wall propagation and GMI effect. For interpretation of observed changes of hysteresis loops after stress annealing we considered internal stresses relaxation and different mechanisms of stress-induced anisotropy. Observed versatile properties of properly processed glass-coated amorphous microwires with enhanced and tuneable soft magnetic properties make them suitable for various applications.

Keywords: amorphous materials, soft magnetic materials, GMI effect, domain wall propagation, ensor applications.

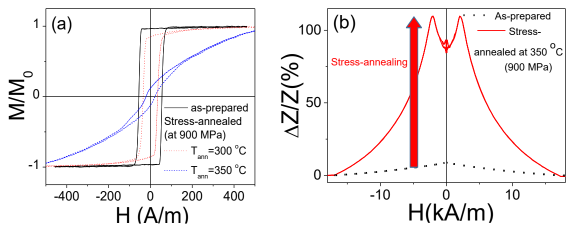

Figure 1: Hysteresis loops of as-prepared and stress annealed Fe-rich (λ_s >0) microwires (a), and GMI effect of as-prepared and stress annealed Fe-rich microwires (b).

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Integrated Experimental and Computational Tools for Smart Corrosion Prediction in Organic-Coated Metals

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Abstract

In the advanced materials industry, there is a growing shift toward sustainable solutions, and this trend is clearly reflected in the development of metals. Today, metals are typically engineered for lifespans ranging from 10 to 25 years, though their actual durability heavily depends on environmental exposure and the associated ageing processes.

Currently, lifetime and ageing assessments rely on both accelerated laboratory tests and long-term field testing. Accelerated tests, however, often fail to replicate real-world environmental conditions, and their results do not always correlate reliably with actual field performance. On the other hand, field tests can take 5 to 10 years to deliver meaningful data, significantly slowing down innovation.

Our long-term scientific goal is to establish a comprehensive knowledge and technology platform capable of predicting the durability and estimating the lifetime of smart organic-coated metals under long-term environmental ageing and corrosion. Achieving this is a complex challenge, as corrosion of organic-coated metals involves a dynamic interplay of multiple physical phenomena that must be characterized under real conditions and accurately modelled.

At VUB, our research focuses on advancing both experimental and modelling approaches. We are combining novel electrochemical techniques with in situ surface analysis, developing sophisticated multiscale electrochemical models, and more recently, incorporating sensor and machine learning into our work.

This presentation will conclude with an introduction to the recently launched **VIPCOAT** project, funded by the European Union under the Horizon 2020 program. VIPCOAT brings together twelve partners from seven countries, coordinated by the Helmholtz-Zentrum Hereon, to make corrosion protection technologies more sustainable, economical, and efficient.

The aim of VIPCOAT is to develop an **open innovation platform** that will assist engineers in designing smart coating materials and creating accelerated life test scenarios to predict their long-term durability. Initially focused on the aeronautics sector, the platform will later expand to other industries through interoperable applications based on standardized European Materials Modelling Ontologies.

Acknowledgements:

VIPCOAT project H2020-NMBP-TO-IND-2020, Grant Agreement 952903. We gratefully acknowledge all VUB-SURF and TU Delft-CTE colleagues for their valuable collaboration.

Plasmonic Single-Molecule Affinity Detection at 10−20 Molar

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Abstract:
DNA can be readily amplified through replication, enabling the detection of a single-target copy. A comparable performance for proteins in immunoassays has yet to be fully assessed. Surface-plasmon-resonance (SPR) serves as a probe capable of performing assays at concentrations typically around 10−9 molar. In this study1, plasmonic single-molecule assays for both proteins and DNA are demonstrated, achieving limits-of-detections (LODs) as low as 10− 20 molar (1 ± 1 molecule in 0.1 mL), even in human serum, in 1 h. This represents an improvement in typical SPR LODs by eleven orders-of-magnitude. The single-molecule SPR assay is achieved with a millimeter-wide surface functionalized with a physisorbed biolayer comprising trillions of recognition-elements (antibodies or protein–probe complexes) which undergo an acidic or alkaline pH-conditioning. Potentiometric and surface-probing imaging experiments reveal the phenomenon underlying this extraordinary performance enhancement. The data suggest an unexplored amplification process within the biomaterial, where pH-conditioning, driving the biolayer in a metastable state, induces a self-propagating aggregation of partially misfolded proteins, following single-affinity binding. This process triggers an electrostatic rearrangement, resulting in the displacement of a charge equivalent to 1.5e per 102 recognition elements. Such findings open new opportunities for reliable SPR-based biosensing at the physical detection limits.

Keywords: Single-molecule detection, surface plasmon resonance (SPR), proteins, DNA, Limit of detection (LOD), amplification, pH-conditioning, Biolayer metastability.

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