

Werner Prize 2005 Laureate

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**Physical Chemistry of Dust:
From Atmospheric Aerosols to Drug Nanoparticles**

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This contribution is devoted to the investigation of large molecular aggregates with sizes ranging from less than nanometers up to microns, i. e. with dust particles. Such particles bridge the gap between small molecular aggregates and the bulk phase. With molecules as building blocks it is immediately clear that the particles are held together by rather weak intermolecular forces (Van der Waals forces and hydrogen bonds). This is in contrast to the strong chemical bonds within the molecules themselves. The present contribution shows that this hierarchy of forces has a decisive influence on the particles' properties.

Particulate matter built from molecules plays an important role in various fields ranging from astrophysics to atmospheric sciences and to medical applications. In all these fields physical chemistry plays a crucial role to get at a better understanding of this special form of matter. As illustrated by various examples, the key objective of our research is thus the controlled generation and detailed characterization of such molecular particles using many different physical-chemical methods.

Invited lecture

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Chemical Sensing Using Metal Nanowire Arrays

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Semiconductor nanowires can be used to detect the binding of charged analyte molecules. The physics of this transduction process are identical to those operating in a field-effect transistor. However in view of the frenzied pace of research relating to nanowire synthesis, remarkably few publications report advances in semiconductor nanowire-based sensing. Progress in this direction has been impeded by the intrinsic instability of semiconductor nanowires toward corrosion in humid air and aqueous solutions. Noble metal nanowires have attributes including strength, ductility, and chemical stability making them attractive candidates for chemical sensing. However, unlike semiconductor nanowires, the conductivity of metal nanowires is not responsive to "charge gating" induced by the presence at the surface of the nanowire of bound ions. Consequently the properties of metal nanowires for chemical sensing have not been explored.

We have developed a new method for preparing arrays of noble metal nanowires that involves the electrodeposition of metals (Pd, Ag, Pt, Au) onto stepped graphite surfaces. Metal is electrodeposited selectively at step edges on the graphite surface leading to polycrystalline nanowires that are up to 1 mm in length and 30-500 nm in diameter. These nanowires adhere weakly to the graphite surface and arrays of hundreds of wires may be transferred onto glass surfaces using an embedding process. These transferred nanowires form the basis for chemical sensors in which the resistance of the nanowire array is modulated by molecules that chemisorb at the surfaces of these metals. Two examples involve palladium nanowires in the presence of hydrogen, and silver nanowires in the presence of amines. For both of these systems, the changes in resistance (R/R_0) can be 1000% or more. What is the origin of these enormous and unexpected resistance changes? In this talk, we focus attention on this issue and we discuss the prospects for developing practical chemical sensors based on these novel mechanisms.

Grammaticakis-Neumann Prize 2005 Laureate

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Exciting Supramolecular Assemblies

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Supramolecular self-assembly has played a major role in the move from isolated molecules to complex, interactive ensembles, and a wide variety of well-defined supramolecular architectures have been prepared to date. In this area, our approach is characterized by the combination of photochemical and supramolecular perspectives. By combining molecular recognition units with chromophores, it is possible to use complementary molecules to bind and orient the photoactive units prior to excitation. The ensuing control of the photoinduced process is reminiscent of topochemical transformations occurring in the solid and has been demonstrated for cinnamates, stilbenes chromophore, and fullerenes. The templates serve to direct the preferential formation of specific photodimers with accrued yield and regioselectivity. By combining different recognition motifs (eg metal ion complexation and hydrogen-bonding), one can construct systems responding to multiple chemical inputs. The supramolecular structures thus prepared can themselves serve as templates for the subsequent assembly of polymeric systems, as well as for the construction of photonic devices in which the active centers are juxtaposed in a linear arrangement.

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Invited lecture

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Microfluidics for Bioanalytical Applications

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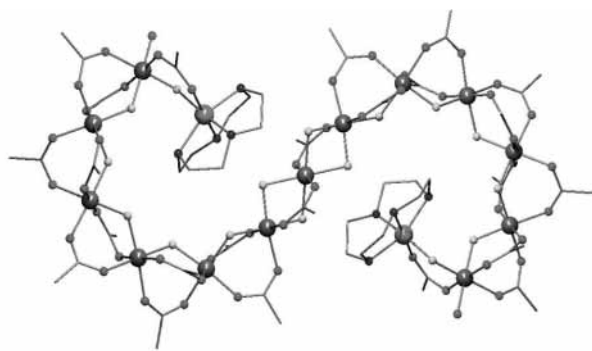
Microtechnology has started to impact many areas of biology and chemistry by providing new sensing and analytical tools. Microfluidics emerge as one of the most promising platforms derived from microtechnology, where the currencies are nanoliters for reaction volumes, micrometers for dimensions, and milliseconds for diffusion and reaction times. We are developing microfluidics that can be used to miniaturize biological assays and in particular surface fluorescence immunoassays.^[1] Samples and reagents are moved in these microfluidic devices by means of capillary forces only.^[2] These devices are therefore simple to use, free of peripheral equipment, and portable. They can be used to screen many analytes from different solutions in parallel, in a combinatorial fashion, with great economy of samples and reagents, with a sensitivity attaining 1 pM, and within only minutes.^[3] We expect various applications in life sciences and medicine to benefit from this technology, typically if samples are available in limited volume (i.e. 1 microliter or less) or a short time to result is desirable, as is the case with assays using cell cultures or with some *in vitro* diagnostics for near-patient testing in hospitals.^[4,5]

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Invited lecture

Studies of Heterometallic Wheels and ChainsRichard WinpennyDepartment of Chemistry, University of Manchester,
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The reaction of chromium fluoride with carboxylic acids in the presence of an amine template and a source of a second metal leads to a series of heterometallic wheels and chain complexes, the structures of which can be controlled by the amine template. These are the first heterometallic ring compounds known. For secondary amines such as dimethyl or diethylamine octanuclear wheels, $[\text{Cr}_7\text{MF}_8(\text{O}_2\text{CR})_{16}]^-$ are formed ($\text{M} = \text{Ni}, \text{Co}, \text{Mn}, \text{Fe}, \text{Cd}, \text{Zn}$). The spin ground states of the wheels depend on the second metal present. $\{\text{Cr}_7\text{Ni}\}$ has been studied in detail as a possible qubit. For branched secondary amines nonanuclear wheels result – the first large odd-numbered cyclic complexes. For macrocyclic amines more sophisticated structures can be prepared such as the S-shaped pentadecanuclear cage shown below. We can also link the rings together and attach them to surfaces. A range of techniques will be discussed as applied to this unique family of molecules.



5 Invited lecture

Clusters and Nanoparticles - Their Use in CatalysisBrian F. G. JohnsonDepartment of Chemistry, Cambridge University,
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The preparation and characterisation of mixed metal nanocatalysts for a variety of chemical conversions will be reported together with work on the production of carbon nanotubes for commercial use, using similar catalysts.

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