Gold Nanoparticles for Physics, Chemistry and Biology

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The gold played a great fascination in every century and its use in the form of nanoparticles is related to the history of red-coloured glass born probably in Egypt and Mesopotamia in 1400-1300 BCE. However, the first milestone in the history of gold ruby glass is represented from the Roman Lycurgus cap that, dated to the fourth century has revealed today by electronic microscopy, the presence of minute amounts of gold (about 40 ppm) and silver (about 300 ppm) of 5-100 nm in diameter. It is interesting to underline that gold nanoparticles (AuNPs) exhibit a rich array of interesting and important catalytic properties, which has sparked a huge interest in gold-based systems in several interdisciplinary areas.

All the topics of interest on this unusual metal are reported in this book, organized in 13 chapters with an introductory Preface.

Gold possesses a unique combination of physical and chemical properties in both the macroscopic and microscopic states; on the macroscopic scale it is know for its unique yellow color, as well as for its chemical stability and high redox potential. On the nanoscale, its unusual electronic configuration, made by high ratio of surface atoms to bulk atoms, results in particular electromagnetic properties and quantum effects. Thus AuNPs, for example, as colloidal nanoparticles (CNP) have resilient properties compared to other inorganic nanoparticles, such as unique plasmon-resonance, optical properties and a bioconjugation surface for molecular probe. These unique properties have drawn attention with a view to developing a totally different method in the field of nanomedicine.

Colloidal AuNPs has been used as carrier of antitumoral drugs, antibodies, and other drugs for selective killing of diseased cells and microbes, not for their own antimicrobial activity, but for the more significant antimicrobial effect showed when coupled with antibiotics. In other fields AuNPs have shown an interesting role as catalysts for important reactions such as those occurring in the exhaust of internal combustion engines or in electrocatalytic and photocatalytic processes. Naturally the size of the gold particles to be prepared on supports depends on the further use of the materials. For catalysis, very small particles are needed, generally smaller than 5 nm, while for physics or biology larger particles can be required.AuNPs can also be deposited on organic supports or embedded in organic materials leading to hybrid inorganic-organic materials for applications in life science.However, nanometer-sized gold nanoparticles are of fundamental and practical interest, as their chemical, electronic, and optical properties can potentially be exploited for different applications.

These properties are, in fact, extremely dependent upon their size and shape. At this purpose, numerous approaches to synthetically and sistematically control morphology electrical charge and surface composition have been developed in recent years, as well as many methods to prepare gold nanostructures, including electrochemical, gas and liquid phase methods. All these methods are necessary to exploit and better understand the unique properties and structures of these nanoparticles for the many and possible practical applications.

The structure and geometry of the surface atoms of gold in liquid phase, generally referred to as a *monolayer protected cluster*, is different from that of central atoms, and forms surface facets and edges that dominate catalytic activity. The surface protecting ligands are anchored on the surface atoms, stabilizing their structure, and sometimes provide surface functionality that influences the chemical nature of the particles in solution. In any way gold nanoparticles are classified into types according to their size and size-dependent properties: size ranges of less than 2 nm, 2-10 nm, and -0-300 nm.

Particles smaller than 2 nm in diameter are called gold clusters, which consist of a few ten to a few hundreds of gold atoms. Because of their outstanding properties, gold nanoparticles can find applications in fields in a wide range of areas, including chemical or biological sensors, imaging, medical materials, catalysis for organic chemical synthesis, and energy generation.

Consequently, easy, rapid, and large-scale synthesis, and diverse and stable surface treatments of these nanoparticles are still required, and this is the reason why a better understanding of the unique properties of hold surfaces in the nanometer size regime are currently being performed. Thus, the convergence of nanotechnology, health, and optics based on the extraordinary optical properties of AuNPs supporting Localized Surface Plasmon (LPS) Resonances. For AuNPs such resonances occur in the visible range of the spectrum and their features are determined by the particle geometry and environment. Upon suitable illumination matching the resonance conditions, the light is efficiently coupled to, the nanoparticles. Part of the coupled light is efficiently scattered: (1) in the near field.

Leading to an enhanced field at the particle surface, and (2) to the far field, the NP acting as an efficient optical antenna. The remaining part of the energy is absorbed and dissipated into heat, creating an increase of the metal temperature. Thus AuNPs offer a set of new opportunities to improve diagnosis and therapy of diseases such as cancer. They, in fact, may be used for carrying anti-tumour drugs. These metal-nanoparticles can be transported into the cancer cells being encapsulated in advance with molecules having a high affinity for the proteins, expressed only by the tumour. In conclusion AuNPs have shown to possess unique and useful chemical and physical properties. This is the reason why they are used in many fields, such as diagnostic assays, as specialized stains for electronic microscopy, as the colouring agent in niche glassware and ceramics, in high-end decorative inks, and in some electronics as sinter inks.

Many are the other potential applications in progress in the high-technology domain of AuNPs with high added values, so that the value of the gold they contain is insignificant as a proportion of the final cost.Finally, also if the lethality of AuNPs per se is relatively low and pure metallic gold is non-toxic and non-irritating when it is ingested, research into nanotoxicology and particularly nano-ecotoxicology is still at an early stage, and more data is needed before gold nanoparticles can be used safety for diagnostic or therapeutic purpose.

As conclusive remarks, also if the fascination with gold is a story which spans millenia, this interesting book reporting a great quantity of news on the process methods, chemical and physical pro-

perties an uses of this metal in the nanustructured forms opens an interesting window of interest not only for graduated students in chemistry and physics, but also for the Medical and Chemical Community, wishing to better understanding the potentiality of the nanostructures in general, and the gold nanoparticles in particular.

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