Surfactant-Free Sub-nanometric Copper Clusters. Synthesis, Characterization and Properties

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Sub-nanometric metal clusters formed only by tens of metal atoms and dimensions comparable to the Fermi wavelength of an electron, are attracting considerable attention during the last years. Due to the strong quantum effects, they exhibit unique and dramatic size-dependent properties such as photoluminescence, magnetism, circular dichroism, molecule-like energy gaps or catalytic activity, which makes them useful as building blocks to construct nano/micro structures with potential applications in fields such as biosensing, nanomedicine, nanoelectronics, catalysis, etc.
To date, the most of the chemical methods reported in the literature to prepare metal nanoclusters are based on the use of protecting ligands such as thiols, amides or phosphines. However, the presence of such stabilizing agents compromise most of the emergent applications of clusters such as catalysis. Kinetic control techniques [1] based on the use of electrochemical methods offer a very simplistic way to overcome these problems. By using such approach, Au and Ag nanoclusters in the range 2-10 atoms with enhanced catalytic [2] and biological activity [3] were already synthesized by our group without the needed to use any stabilizing and capping agent.
Among the metals, Cu is widely used in industry because of its high conductivity, similar properties to gold and silver and especially much lower cost [3]. However, due to the lack of efficient synthetic processes, reports about copper clusters are still scarce. Here, we present the recent advances in the synthesis of Cu sub-nanometric naked clusters less than 10 atoms by using a simple electrochemical method. The main effective reaction parameters (i.e. current density, voltage, electrode area, time reaction, and electrode roughness) affecting the cluster size and reaction kinetics will be discussed. Clusters were characterized by UV-Vis spectroscopy, Fluorescence Spectroscopy and Mass Spectroscopy.

REFERENCES

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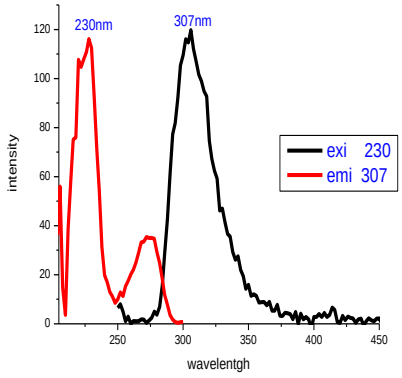

Figure 1: Fluorescence spectroscopy of Cu5 clusters