Electrochemiluminescence meets nanotechnology: theory and practice of the silica nanoparticles approach

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Abstract

Electrochemiluminescence (ECL) is a leading technique in bioanalysis.1 Since the excited species are produced with an electrochemical stimulus rather than with a light excitation source, ECL displays improved signal-to-noise ratio compared to photoluminescence, with minimized effects due to light scattering and luminescence background.2
In the quest for ever-increasing sensitivities, ECL can ideally be coupled to nanotechnology and supramolecular chemistry to develop new systems and strategies for analyte determination also in very complex matrices.3,4 In particular, dye-doped silica nanoparticles(DDSNs) present many advantages: they can be obtained with accessible synthetic schemes, are intrinsically hydrophilic, and, thanks to silica chemistry, are prone to bioconjugation. Very bright systems can be obtained with this approach and DDSNs assume the photophysical properties of the dye accumulated within the nanoparticle.4 In DDSNs, light emission is influenced by the combination of several factors that make DDSNs complex multichromophoric structures. When ECL comes into play, the scenario is even more complicated by the presence of the coreactant–NP interactions. Such complex scenario was approached at the theoretical level by developing suitable mechanistic models for ECL generation5 while, at the same time, the influence of doping level on ECL efficiency was evaluated. The results showed that the ECL intensity of a nanosized system cannot be merely incremented acting on doping, since other parameters come into play. These studies provide valuable indications for the design of more efficient ECL nano-and micro-sized labels for ultrasensitive bioanalysis.

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