Gold Nanoparticles Chemiresistors for Selective Potassium Ions Sensing

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The combination of metal nanoparticles (NPs) with ad hoc supramolecular receptors of the analyte of choice represents a powerful strategy for the fabrication of novel hybrid plasmonic sensors.[1] On the one hand, AuNPs are ideal scaffolds because of their highest surface-to-volume ratio combined with their unique optical and electrical properties.[2] On the other hand, supramolecular recognition has proven to be key to the realization of sensors exhibiting detection limits down to ppm/ppb levels with fast response speed combined with unprecedented selectivity.[3] Potassium ion is an essential element and one of the most abundant physiological metal ions in living organisms. In this context, the development of effective methods to detect K^+ concentration is urgently needed and significant because several diseases could be caused referring to the abnormal K^+ levels in living organisms.
Here, we have devised a novel chemiresistor (CR) capable to perform real-time sensing of potassium ions. Such device is based on the use of all-covalent 3D networks obtained by interconnecting AuNPs with dithiolated crown ethers, which act as both molecular linker and supramolecular receptor. In the present case, we have performed the layer-by-layer assembly of AuNPs on a substrate with photolitographically patterned electrodes (See Figure 1). The potassium adsorption/desorption into the AuNP-based network can determine a modification of the network's structure (e.g. via swelling) and/or electronic properties (e.g. via a change in the device capacitance). The performance of such devices was studied and optimized in terms of NPs size as well as the geometry of the gold interdigitated electrodes. The selectivity of the system was analysed against the most common metal cations found in body fluids (K^+, Na^+, Ca^{2+} and Mg^{2+}). Finally, to demonstrate the sensing capabilities of these hybrid nanocomposites we have performed the real time detection of potassium ions in water and in a real body fluid.
The ultimate goal is to develop a point of care technology that can be implemented in portable optoelectronic devices, whose performance can compete with state-of-art devices within this field of interest.

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FIGURES

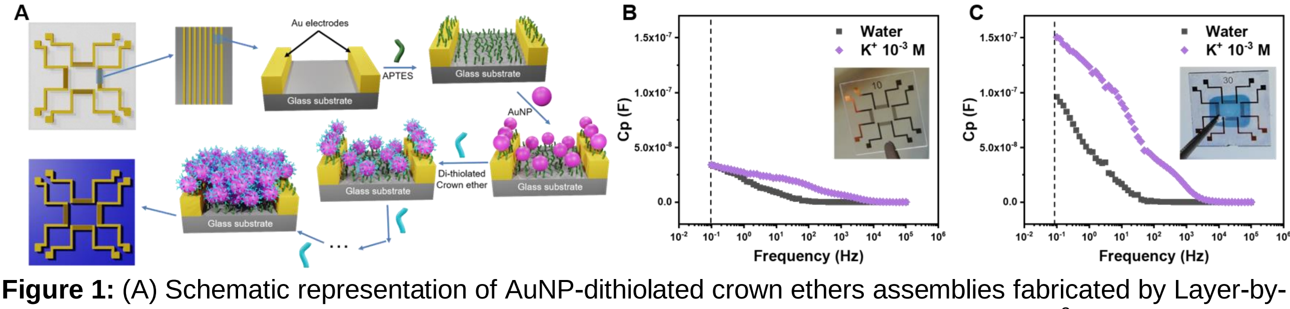

Figure 1: (A) Schematic representation of AuNP-dithiolated crown ethers assemblies fabricated by Layer-by-Layer deposition, (B-C) Capacitance response of devices in water (black curves) or K^+ 10^{-3} M (purple curves) in the absence (B) or presence (C) of the 3D network of AuNPs. The inset show the optical image of the device without (B) and with (C) the 3D network of AuNPs.