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Robust gold nanoparticles stabilized by trithiol for application in chemiresistive sensors

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Abstract
The use of gold nanoparticles coated with an organic monolayer of thiol for application in chemiresistive sensors was initiated in the late 1990s; since then, such types of sensors have been widely pursued due to their high sensitivities and reversible responses to volatile organic compounds (VOCs). However, a major issue for chemical sensors based on thiol-capped gold nanoparticles is their poor long-term stability as a result of slow degradation of the monothiol-to-gold bonds. We have devised a strategy to overcome this limitation by synthesizing a more robust system using Au nanoparticles capped by trithiol ligands. Compared to its monothiol counterpart, the new system is significantly more stable and also shows improved sensitivity towards different types of polar or non-polar VOCs. Thus, the trithiol–Au nanosensor shows great promise for use in real world applications.

(Some figures in this article are in colour only in the electronic version)

1. Introduction

The development of cost-effective, microminiature gas chemical sensors that exhibit fast response time and have high sensitivity and selectivity has long been a major pursuit of nanoscience and nanotechnology [1–5]. The use of nanoparticle materials, with a scale of a few nanometers to approximately 100 nm, has enabled new types of sensors that are capable of detecting extremely small amounts of analytes such as chemical vapors in the range of a few parts per million (ppm). Among the various sensing techniques, chemiresistive sensors based on nanoparticle/polymer thin films, which consist of networks of nanoparticle cores surrounded by an organic moiety show great promise due to their low power consumption, simplicity in fabrication and operation, and their potential for reliable detection [6–10]. When a thin film absorbs gas molecules, the electrical resistance of the film changes, which can be used for qualitative or quantitative analysis to detect the presence, type, and amount of analytes. In recent years, chemiresistive sensors based upon thin films of phthalocyanine, conjugated polymers, or carbon nanotubes have been developed to detect a wide range of vapor analytes [11–13]. Early research on gold nanoparticle-based chemiresistors dates back to 1998 when Wohltjen and Snow were the first to demonstrate a type of chemical vapor sensor using alkanethiol-protected gold nanoparticles as the sensing material [14]. The stability, reproducibility, and 'processibility' of these sensors were found to be superior to other existing systems and extensive work has been reported since then to further develop this type of sensor [15–20].

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