Abstract

This project is concerned with the rapid detection of live bacteria by analysis of the headspace above bacterial cultures. Live/dead testing is important because it can be used to determine antibiotic susceptibility and therefore allow best treatment for infection to be selected for a given patient. Rapid testing is useful both because it allows the correct treatment to be administered earlier and because it reduces the amount of broad-spectrum antibiotic that is used before the optimum treatment has been determined. In this work insitu surface-enhanced Raman spectroscopy is used to detect vapour phase dimethyl disulphide (DMDS), which is a metabolic product of live bacteria. The experiments are carried out in a model system which is the headspace above dimethyl disulphide (DMDS) solution. The measurements actually detect the characteristic bands from chemisorbed methyl sulphide which is created by dissociation of adsorbed DMDS on the surface of Ag and Au nanoparticles. A variety of enhancing substrates were used, the first were arrays of Ag and Au nanoparticles which were deposited on a glass substrate from a layer of nanoparticles trapped at a liquid/liquid interface (a so-called metal-like liquid film or MELLF). These were contrasted with surface-exposed nanoparticle sheets (SENS) where a layer of particles was fixed to a polymer backing. These films showed the expected rise in signal over a timescale of minutes although the rate of adsorption was faster than previously observed. The general observation has been that Ag films give larger signals but slower response while the Au films respond more rapidly but give lower signal intensities. In order to enhance the AgSENS two different general approaches were applied. The first approach was to deposit a Au layer on the AgSENS in an attempt to increase the rate of chemisorption while retaining the enhancement of the underlying silver substrate. Both sputtering and Galvanic replacement were attempted but neither gave the hoped for increase. The second approach was to prepare different Ag nanoparticles whose performance has been claimed to be superior to those used in the original studies. For this approach, Ag nanoparticles were prepared using ethylene glycol rather than traditional citrate reduction, along with polyvinylpyrolidone (PVP). The product nanowires gave very good SERS results. Further studies showed that it was the PVP which improved the rate of adsorption rather than particle shape and the best results for all substrates were obtained by treating a standard Ag SENS with PVP at moderate concentration to introduce a functional surface layer. This work now provides much improved substrates for detection of DMDS. The next steps will be to use these substrates to detect DMDS above bacterial cultures. This will be to confirm that DMDS is produced by a large range of different species of bacteria, rather than the small number tested so far. It is also necessary to confirm that the modified substrates do not also detect other interfering compounds which could also be adsorbed from the hundreds of other molecules that are also present in the headspace above the bacterial colonies. Finally, the objective is to develop and test a system which can be used for rapid screening of antibiotics against bacterial cultures.