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Short communication

Localized surface plasmon resonance based highly sensitive room temperature pH sensor for detection and quantification of ammonia

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ABSTRACT

Ammonia sensor which works in acidic region was developed using metallic copper nanoparticles. The change in localized surface plasmon resonance profile of copper nanoparticles was studied by varying the pH of the solution from 1 to 12. At low pH ranges, the colloidal system shows the copper quantum dot nature and the SPR peak is obtained at the infra red region. At high pH ranges, the resonance peak is shifted into the visible region which is an important property of a pH based colorimetric sensor. Using this property, we successfully designed and calibrated liquid phase and gaseous phase ammonia sensors at very low concentrations (up to 20 ppm). The sensor shows very good photo stability and thermal stability which depends on the pH of the solution. Using cotton plug, gaseous phase ammonia sensor was constructed and sensitivity was confirmed. At very low pH, the concentration of the ammonia solution is directly proportional to the absorbance and obeys Beer–Lambert's law.

1. Introduction

Noble metal nanoparticles show unique optical properties and chemical stability, which is an ideal probe for studying bio-systems. The efficient scattering properties allow the visualization of individual nanopatrticles [1–6].

Surface plasmon resonance is an effective method for the study of optical properties of nanoparticles and it has been successfully applied to the sensor system. These are highly sensitive due to the resonance dependence of the parameters of the electromagnetic radiation. The sensor sensitivity and stability depends up on properties of the surfactant and medium. Sensitivity of the SPR sensor can be defined as the derivative of monitored SPR parameter (resonant angle, wavelength or absorbance) with respect to the parameter to be determined (index of refraction, concentration, etc.) [7–11]. Implementation of a dielectric material over the nanoparticle produces a red shift in the extinction curve. SPR based pH sensors comprises an opto-chemical system, which interrelates optical and bio-chemical domains [12–14].

Biosensors measure the change in fluorescence or the change in absorbance caused by the products generated by catalytic reaction. They also measure the changes induced in the intrinsic optical properties of the biosensor surface, due to the surface functionalization of dielectric molecules like proteins or amino acids [15–18].

Detection and quantification of ammonia is very important in the field of clinical diagnosis as well as in the monitoring of environmental pollution. Ammonia is one of the most harmful gases with irritating smell and contributes strongly towards environmental pollution and originates from various sources such as chemical combustion, electronic industry, medical treatment etc. [19,20]. Ammonia can cause serious health issues such as irritation of eyes, skin and respiratory disorder, etc. and could even lead to pulmonary edema at lower doses [21]. Also, ammonia is released in the exhaled gas during breathing, under certain conditions of diseases such as peptic ulcer caused by the infection of bacteria, *Helicobacter pylori* [22]. Therefore, development of ammonia sensor in both gaseous and liquid phases is highly demanding for various applications. Several methods such as colorimetric, amperometric and fluorimetric are used for the detection of ammonia in liquid phase as well as gaseous phase [17,23–28].

In this work, we came up with a novel method to study and tune the surface plasmon resonance of copper nanoparticles coated with L-Cystine into the visible region at different pH values ranging from 1 to 12 and developed ammonia sensors with very high sensitivity. This method can be employed for the detection of ammonia in liquid phase as well as gaseous phase.

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