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Abstract

Refractive Index Sensitivity of Localized Surface Plasmon Resonance Sensor Using Gold Nanotriangles Synthesized by Seedless Non-Thermal Liquid-Phase Reduction †

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Abstract: This paper reported the refractive index sensing ability of localized surface plasmon resonance (LSPR) sensors using synthesized GNTs by a seedless and non-thermal synthesis method. The synthesized GNTs were a blue solution, and the edge length of the GNTs was 127 nm. The refractive index sensitivity of the LSPR sensor using GNTs showed 162 nm/RIU, and the results confirmed that the LSPR sensor using GNTs realized high refractive index sensitivity compared with that using spherical gold nanoparticles (GNPs) with a Au concentration of 0.186 mM and a diameter of 10 nm.

Keywords: nanotriangles; LSPR sensor; refractive index; absorbance; synthesis

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1. Introduction

A localized surface plasmon resonance (LSPR) sensor using a glass substrate fixed with gold nanoparticles (GNPs) can be realized for the refractive index sensing of a solvent [1]. However, the sensitivity of LSPR sensors using GNPs depends on the size distribution of particles, and the improvement in sensitivity requires GNPs with a uniform particle size deriving sharpened LSPR peaks [2]. The blue-colored gold nanotriangles (GNTs) with an edge length of around 100 nm have a sharpened LSPR peak at a wavelength of approximately 600 nm [3]. Since the LSPR peak of the GNTs with blue color is sharp in comparison with that of spherical GNPs, we expect to improve the sensitivity of the LSPR sensor.

The GNTs can be synthesized by thermal liquid-phase reduction using citric acid and cetyltrimethylammonium bromide (CTAB) [3]. However, since the thermal reduction requires precise temperature control of the solution, it is difficult to realize the reproducible synthesis of GNTs with an edge length of around 100 nm. To overcome these issues, we developed a reproducible synthesis method of GNTs in one-pot non-thermal liquid-phase reduction using a mixture of sodium citrate and tannic acids as reducing reagents. In this study, the refractive index sensing ability of the LSPR sensor using synthesized GNTs was reported for the first time.

2. Materials and Methods

A mixture of the aqueous solutions of sodium citrate (128 µL, 100 mM) and tannic acid (7.7 mL, 0.153 mM) was prepared as solution A. A mixture of the aqueous solutions of hydrogen tetrachloroaurate (III) tetrahydrate (0.21 mL, 29.7 mM) and CTAB (4.8 mL, 9.15 mM) was prepared as solution B. Subsequently, solution A was added to solution B while stirring, and the mixture was stirred for 10 min at room temperature (23 °C). The solution was allowed to stand at room temperature for three days. The LSPR peak of the synthesized GNTs solution was recorded using a UV–visible spectrometer, and the shapes of GNTs were observed using TEM.

The LSPR sensor was produced, where a glass substrate coated by the amino group was immersed in synthesized GNTs solution (Au concentration of 0.186 mM) for 24 h and dried for 24 h. The absorption spectrum of the produced LSPR sensor fixed in a solution-filled quartz cell using a specified holder was measured. The refractive index sensitivity (nm/RIU) of the sensors was calculated using the slope of the linear approximation of the relationship between the LSPR peak shift and the refractive index of the solution. The results were compared with that of the LSPR sensor using the GNPs solution (Au concentration of 0.186 mM) with a diameter of 10 nm [2].

3. Results and Discussion

The synthesized GNTs exhibited a deep blue color, and the LSPR peak wavelength in the absorbance spectrum of GNTs was 596 nm. The shape of the LSPR peak of the synthesized GNTs was sharp in comparison with that of spherical GNPs (Figure 1a). TEM images of the synthesized GNTs confirmed that the average edge length of GNTs was 127 nm (Figure 1b). In this study, three synthesis experiments of GNTs were conducted, and each sample showed the same color and spectrum. This result confirmed that our synthesis method of GNTs has high reproductivity.

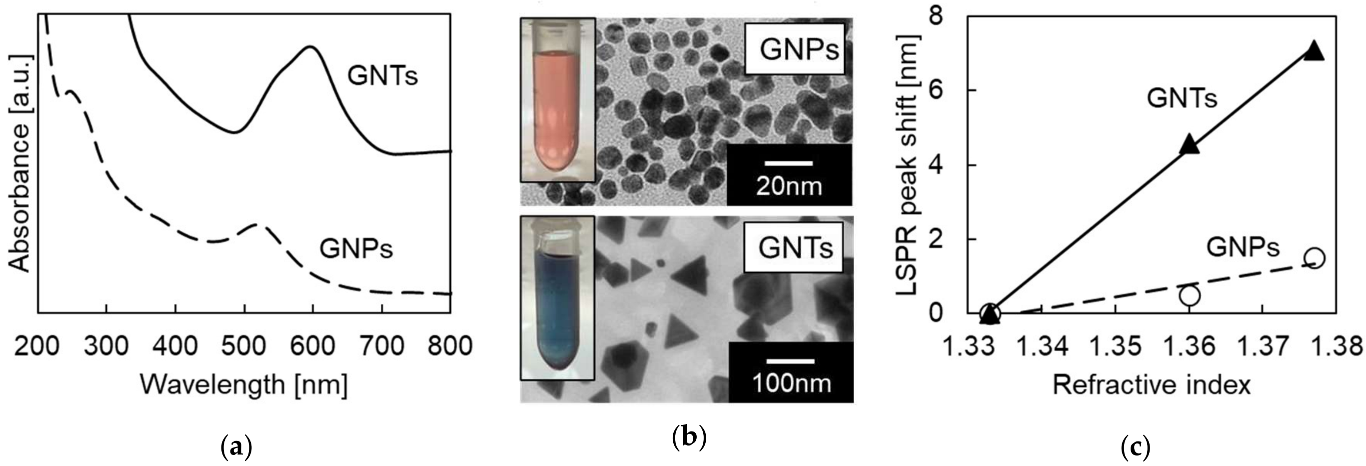

Figure 1. (**a**) UV–vis absorption spectra of GNPs and GNTs solution. (**b**) TEM image of GNPs and GNTs. (**c**) LSPR peak shift of LSPR sensors using GNPs and GNTs as a function of refractive index.

The refractive index sensitivity of the LSPR sensor using the synthesized GNTs was 162 nm/RIU (Figure 1c). On the other hand, the sensitivities of the LSPR sensor using GNPs were 33 nm/RIU [2]. These results confirmed that the LSPR sensor using GNTs realized a high refractive index sensitivity compared with that using spherical GNPs.

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References

1. Okamoto, T.; Yamaguchi, I. Local plasmon sensor with gold colloid monolayers deposited upon glass substrates. *Opt. Lett.* **2000**, *25*, 372–374. [CrossRef]
2. Hamamoto, M.; Yagyu, H. High sensitive LSPR sensor for refractive index of solvent using monodisperse gold nanoparticles. In Proceedings of the 25th International Conference on Miniaturized Systems for Chemistry and Life Sciences (MicroTAS 2021), Palm Springs, CA, USA & Online, 10–14 October 2021; pp. 1465–1466.
3. Kumer, D.V.R.; Kulkarni, A.A.; Prasad, B.L.V. Synthesis of Triangular Gold Nanoplates: Role of Bromide Ion and Temperature. *Colloids Surf. A Physicochem. Eng. Asp.* **2013**, *422*, 181–190. [CrossRef]