Au-Zn Porphyrin Nanocomposite and Application for Analysis Organohalides

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Abstract:

Au-Zn porphyrin nanocomposites have been synthesized using zinc porphyrin and dihydrogen hexachloroplatinate in the presence of light and ascorbic acid. TEM image showed Au particle which the size average was 5 nm. UV-visible spectrum revealed the characteristic peak of Au and Zn porphyrin nanoparticles. The modified electrode exhibited catalytic activity for the reduction of carbon tetrachloride, chloroform, and pentachlorophenol, as three test models at -1.0 V vs Ag/AgCl. The linear range was 0.5 μM up to 8 μM.

1. Introduction

The nanomaterial is the most exciting and fastest growing areas of scientific research. In the nanoscale size region (1-100 nm), the chemical and physical properties of materials can differ significantly from bulk materials. Nanoparticles especially Au metal particles and porphyrin offer several advantages which could potentially be exploited for catalytic applications, photo devices, and other devices. Besides the nanoparticles have many applications as mentioned above, the nanoparticles can apply to use for environmental remediation. The remediation especially reductive dehalogenation has been considerable interesting for study [1].However, all studying of reductive dehalogenation have been performed in homogenous solution and no system has been used as sensor for detection organohalides. In this work is particularly interested in nanoparticles especially Au and Zn porphyrin and apply as senseing for analysis organohalides. These material were chosen because Zn (II) porphyrin exhibited higher catalytic rates than previously used Co (II) porphyrin or Co (I) salen [2]. Furthermore Au nanoparticles are prominent catalyst which promote the electron transfer and lead to enhance catalytic reaction of organohalides. Hence, Au and Zn porphyrin nanocomposites is expected that should enhance the current signal response toward the catalysis of electrochemical reduction of organohalides at low potential with better sensitivity and reproducibility.

2. Methodology

Synthesis Au-Zn porphyrin nanocomposite: Au salt, Zn porphyrin, and ascorbic acid were used as three stock solutions for the Au-Zn porphyrin nanocomposite preparation. A 1-mL sample of Zn porphyrin stock solution was mixed with water. Ascorbic acid was added to the mixture, followed by Au salt stock solution. The resulting solution was exposed to light source for 10 min. After that the solution was examined by transmission electron microscope (TEM) and UV visible.

Electrode Preparation: The Au-Zn porphyrin nanocomposites were dropped on the active electrode surface and dried at room temperature followed by the application of two Nafion layers.

3. Result and Discussion

TEM and UV-Visible Characterization: Gold nanoparticles were formed by chemical reduction due to the presence of ascorbic acid and Au salt. The TEM showed the Au nanoparticles and reveled the size of particles approximately 5 nm. UV-visible showed the characteristic peak of Au nanoparticle which was observed at 280 nm. The Au peak decreased with time, whereas the background absorbance intensity increased due to the formation of large Au nanoparticles. UV-visible spectra during the formation of Au-Zn porphyrin nanocomposites are studied. Characteristic peaks of porphyrin at 430 nm or the Soret band decreased significantly, and the peak at 570 nm almost disappeared after 10 min of light irradiation, while the background absorbance intensity increased drastically.

Determination of halogenated hydrocarbons

GC electrode modified with Au-Zn porphyrin nanocomposites/Nafion showed catalytic reduction of chloroform at -1.0 V vs. Ag/AgCl. Calibration curves were established for chloroform, carbon tetrachloride, and pentachlorophenol, which were reduced at -1.0 V, using the same Pt-Zn porphyrin nanocomposite-modified GC electrode. The three organohalides could be determined from a common calibration curve (linear range from 500 nM to 8 μM, $R^2 = 0.9940$), which indicated the potential of this sensor to provide a general-purpose organohalides sensor.

4. Conclusions

In brief, gold-porphyrin nanocomposites have been synthesized, characterized, and used as sensing materials for analysis of organohalides. The detection limit is sufficient to satisfy regulatory requirements.

5. References

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