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GAS SENSING PROPERTIES OF 2, AMINOBENZOPHENONE-2, CARBOXYLIC ACID THIN FILM PREPARED USING DIPPING TECHNIQUE

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ABSTRACT

Biosensors are the sensitive materials for some particulars application which was built from the bioorganic substances such as protein, lipid and enzyme. These types of sensors show a rapid growing with increasing of the application area such as, environmental, foods industries and medical. This paper reports the use of an amino acid derivative, 2, aminobenzophenone-2, carboxylic acid thin films prepared by dipping technique as sensitive layer to detect several vapor samples, cyclohexane, 2-propanol, acetone and ethanol. The sensing sensitivity was based on the change in the optical properties of the thin film upon exposure toward vapor. It was found that the thin film was sensitive to the presence of the vapor samples by the change of its optical absorption spectrum. The average time to reach the maximum value of the response is within 15 seconds. The responses may recover to its initial state when the vapor molecules driven out from the sensor surface within 10 seconds. The sensor responses towards the samples were distinguishable and reproducible.

Keywords: Amino acid, gas sensor, dipping technique, optical sensing technique

INTRODUCTION

There is an increasing interest on the development of a gas sensor system which features high sensitivity, stability and wide selectivity [1]. The gas sensor has been widely used in many application fields, particularly in the electronic nose application. Recently, many research works have been focused on the exploitation of bioorganic substances as sensing elements in a gas sensors system, for example porphyrins [2], phthalocyanine [3] and protein [4]. Proteins are naturally occurring organic compounds which plays a crucial role in the energy transfer in the mammalian body system. Such important feature of these compounds has yet to be explored for the purpose of the biosensor development and this has set up remarkable efforts to utilize them as a sensing element for gas detection.

This paper reports a study on the application of a derivative of protein compounds, 2-aminobenzhophenone-2, carboxylic acid, as a sensing element for detection of several vapor samples, cyclohexane, 2-propanol, acetone and ethanol. These chemical was prepared into thin film using dipping technique. The sensing sensitivity was based on the change on the optical absorption of the film upon exposure towards the volatile organic compounds (VOC) samples. The sensing characteristic of this thin film towards gas samples will be discussed in detail.

EXPERIMENTAL

An amino acid derivative, 2-aminobenzophenone, 2-carboxylic acid (ABPCA) (see figure 1); was used as sensitive material for detection of VOC vapor. This chemical is commercially available and used directly without further purification process.

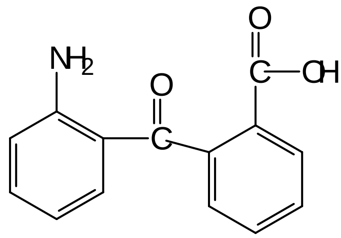

Figure 1. The molecule structure of 2-aminobenzophenone, 2-carboxylic acid.

The thin film of this chemical was prepared using the dipping technique. The solution of ABPCA in ethanol with a concentration of 3.5 mg/ml was prepared. At first, the quartz substrate was immersed in the solution using a dipping tool. The thin film of the ABPCA was built up on quartz substrate by lifting up the substrate at a constant speed of 5 mm/minute. The dipping process was conducted at the room temperature.

The optical properties and the surface morphology structure of the thin films were characterized by UV-VIS spectroscopy and the atomic force microscopy technique (AFM), respectively.

The thin film was used to detect the presence of four VOC samples, cyclohexane, 2-propanol, acetone and ethanol. The detection of vapor was performed using an optical sensor system which has been described elsewhere [5]. The thin film was exposed toward the vapor and measured its optical properties change at the wavelength of 473 nm. The sensitivity of the film was observed and its stability against VOC was studied.

RESULTS AND DISCUSSIONS

The thin film of ABPCA has been successfully deposited on quartz substrate using the dipping technique. Figure 2 shows the optical absorption spectrum of the film. There is an absorption peak appeared in the spectrum, namely at the blue optical field region, 340 nm. The thin film exhibited to have small absorption at a longer wavelength range. A particular peak in the spectrum was ascribed to the $\pi\pi^*$ electronic transition in the benzyl ring or $\pi\pi^*$ transition between carboxyl π orbital and the benzyl ring [6]. The surface morphology characterization has been performed on the as prepared thin films. Figure 3 shows the AFM image and the cross sectional analysis of the thin film surface in the area of 14 x 14 μm^2. The bubbles images on the substrate which was observed to arrange in order manner indicated that the film have been well deposited on the substrate by self assembling of the ABPCA molecules on the adsorption sites of the quartz substrate. However, the height and size of the bubbles varied, this may be due to the formation of molecules aggregation in solution prior to the deposition process. This aggregation may be avoided if we used a lower concentration of the solution. From the surface cross sectional analysis results, it was found that the thin films surface features a rough morphology with the appearance of a large number of small spacing of adjacent hills. The surface roughness of the films was determined by the root means square of available height on the surface. Therefore, the surface roughness of the ABPCA films was 55.30 nm.

The thin film of ABPCA was used to detect the presence of several gas samples, cyclohexane, ethanol, acetone and 2-propanol. The detection of gases was performed by flowing up the vapor sample across the thin film surface. The vapor molecules were interacted with the film surface and created the change on the optical properties of the film. The optical response of the thin film toward vapor was measured by transmitting a light source to the thin films surface and detects the reflected light using a detector and then, the spectrum of the reflected light was analyzed. The comparison of the intensity of the reflected light received by the detector before and after being exposed to vapor was considered as the sensing sensitivity. The recoverability of the thin film toward the presence of vapor was studied by removing the vapor in the chamber and the thin films response was recorded. This experiment was performed at least two cycles at once measurement and repeated this procedure at another time to ensure the films stability against the vapor.

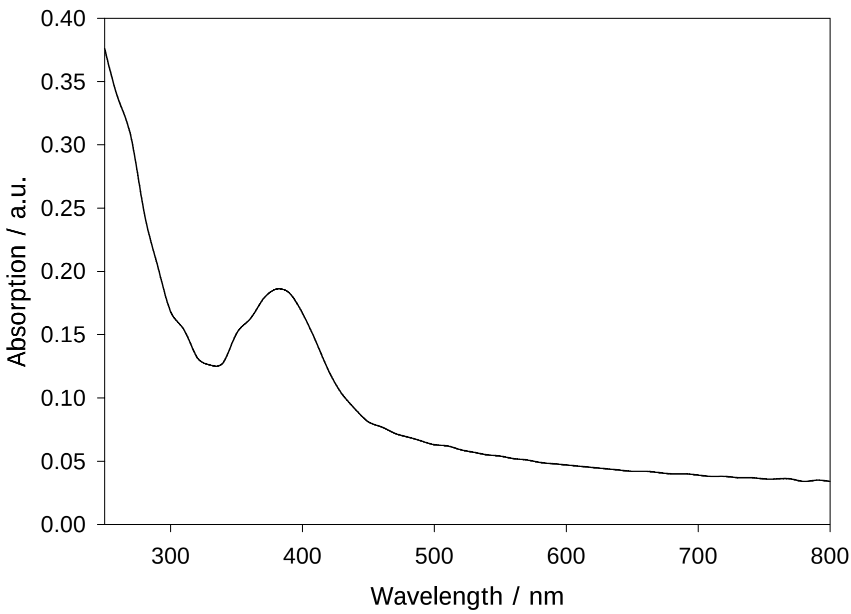

Figure 2. Optical absorption of ABPCA thin film.

Figure 4 shows a typical response of the ABPCA film toward the presence of cyclohexane vapor which was measured at the wavelength of 473 nm, the peak intensity of the light source. The presence of this vapor has reduced its optical absorption. It was observed that the thin film was very sensitive toward this vapor with the average response time to reach the maximum change on the intensity was within 20 seconds. Despite the drift, the response may recover back to the original state when the vapor molecules were removed from the thin films surface. The observed drift may be due to the incomplete desorption process of the vapor molecules from the films surface. This could be overcome by heating the thin film at an appropriate temperature to facilitate a fast desorption process. The detection of the vapor samples were continued to other samples, ethanol, acetone and 2-propanol. Figure 5 shows the thin film responses towards the presence of such vapors. It was observed that the thin films was sensitive to the presence of these vapor with the response time was the same with what has been shown for the cyclohexane vapor. From the experimental result, it was obtained that the responses of the films were different for different vapor samples. Therefore, it can be concluded that the thin films demonstrated a selectivity feature. The response of the thin film was found to be unstable towards the oxygenous gas for the longer time exposure. This could be due to an intense reduction activity of the oxygenous gas with the ABPCA molecules. This resulted in the increasing of the optical absorption of the thin films due to the reduction of a number of electrons in the highest occupied molecular orbital (HOMO) of ABPCA [6].

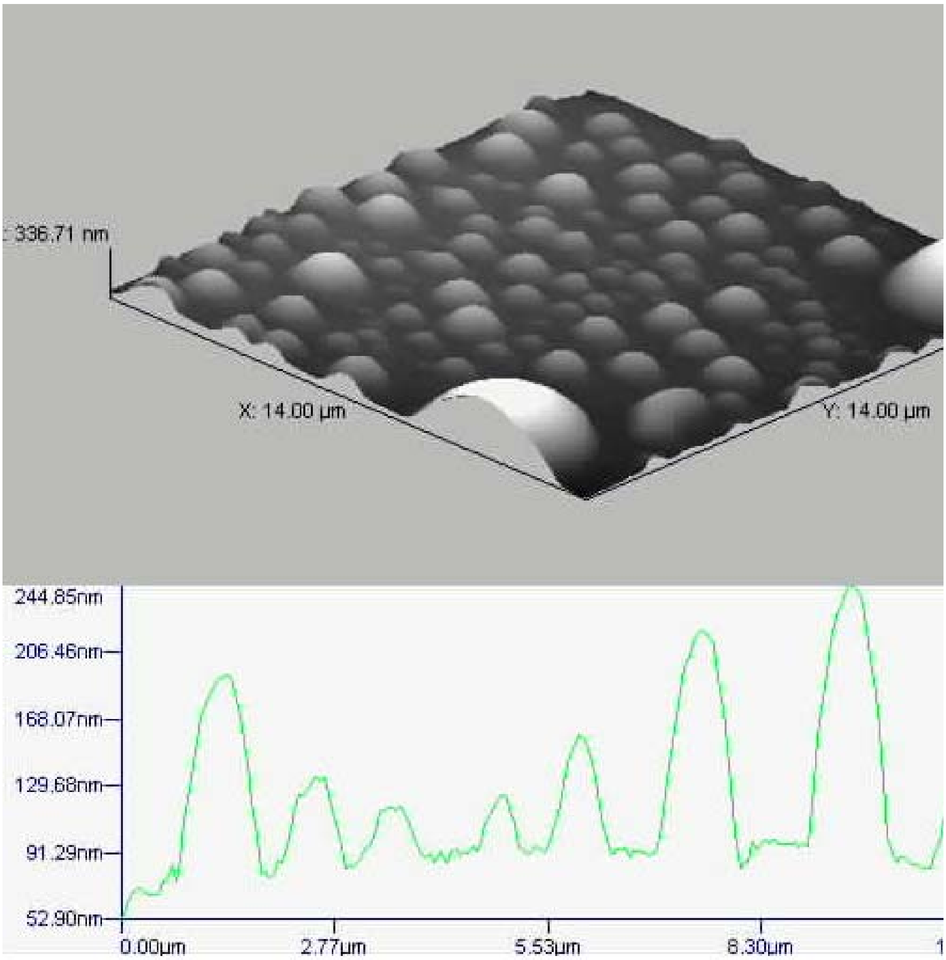

Figure 3. The AFM image and the cross sectional analysis of ABPCA film.

The interaction of gases and amino acid has not yet been explored, particularly their optical responses characteristic. The interaction of molecules of gas with the films surface which ascribed to a successful adsorption process may caused rearrangement of the electrical dipole moment in the bulk volume of film. The change on the dipole in the films was due to a charge transfer (CT) between the electrons of analytes and the electrons of amino in the molecule skeleton. The CT process created the change on the state of two particular orbital of molecule, namely highest occupied molecule orbital

(HOMO) and lowest unoccupied molecule orbital (LUMO). The change could be the narrowing or broadening the distance between these two orbital, where this, in turn, change the amount of the light energy consumed by the electrons in the HOMO to excite to the higher energy level. When a light source passed through the film which has been already interacted with the molecules of gases, the intensity of the light source which entered the detector would change by increasing or decreasing in the light intensity which correspond to the narrowing or broadening of the band gap between HOMO and LUMO [1].

The sensitivity feature of amino molecule toward gases may be determined by the molecule structure and the chemicals properties of amino and analytes, such as reduction oxidation activity and polar behavior. For the case of the structure, the ABPCA film was observed to be sensitive to the gas with planar structure such as cyclohexane which was lead by the coulombic binding activity. However for the chemical properties, the thin film exhibited to be sensitive toward polar molecules and oxigenous gases such as acetone and 2-propanol and ethanol, correspondingly. In this case, the interaction was played by both interactions mechanism where the prominent interaction was due to the electrons donor-acceptor binding. Successful interaction may be ascribed by the nπ and ππ* electrons of amino acid and gases molecules in the HOMO orbital. The sensitivity of

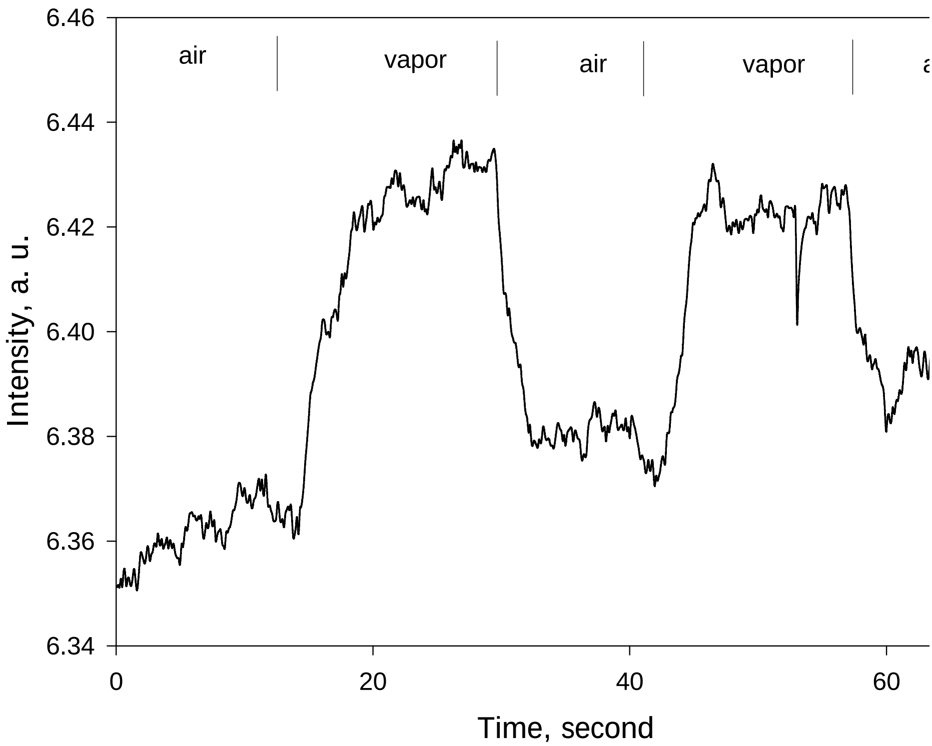

Figure 4. Typical response of the ABPCA film towards the saturated vapor of cyclohexane.

amino derivatives may be adjusted through several substitutions at particular site in the molecule skeleton which may rearrange their oxidation-reduction feature and behavior.

CONCLUSION

The thin film of ABPCA has been used as a sensing element to detect the presence of cyclohexane, ethanol, acetone and 2-propanol vapor. The thin film was found to be sensitive towards the presence of such vapor with fast response time and exhibited a high stability towards the cyclohexane and acetone vapor but low stability for the oxygenous gas such as ethanol and 2-propanol. The response pattern of the film towards various types of VOC samples were found to be different each other and can be easily distinguished.

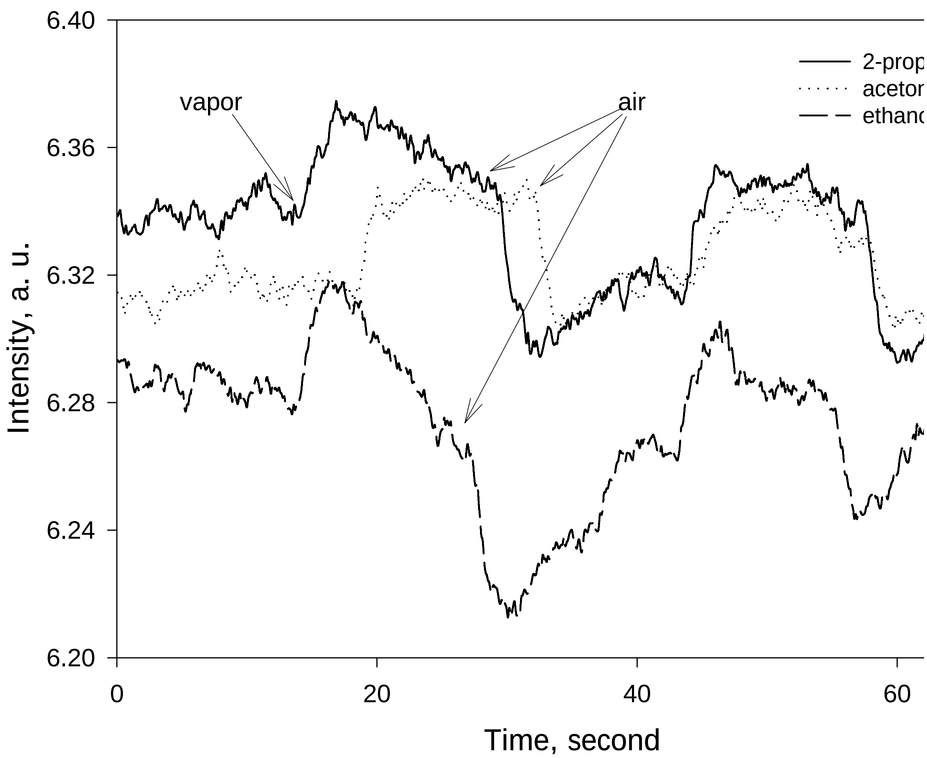

Figure 5. The film responses towards vapor of 2-propanol, ethanol and acetone.

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