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Synthesis of 2-D nanostructures of Bismuth Oxychloride

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TO: Dr. Parag Banerjee
FROM: Howard Kim
DATE: May 3rd 2015
SUBJECT: Independent Project Report

Abstract

This project studies the synthesis process of 2-D nanostructure of inorganic materials. This project studies the ZnO thin layer deposition on a commercial grade paper using Atomic Layer Deposition (ALD) technique and its effectiveness of reducing water permeability. The experiment utilizes a commercial grade blue ink for the testing of the permeability. The purpose of the experiment is to successfully contain the ink on the paper in the ZnO layer without ink seeping out or water seeping in. The measurements of the experimental data will be taken using UV-1800 UV Spectrophotometer (Shimadzu, Columbia, MD) and will be analyzed by comparing to the control data. This report will focus on the construction of Ultraviolet Spectroscopy control data.

Introduction

The main objective of this project is to create a thin atomic layer to create a less water-permeable environment over the layer. In this project, the Manuscript calligraphy blue fountain pen ink (Manuscript Ltd, Shropshire, United Kingdom) was used for testing of the permeability of the layer. Theoretically, since the ALD technique provides a uniform thin layer on the surface, the layer should be able to physically block the substances such as ink molecules traveling over the layer and thus reduce the permeability. Given that this hypothesis is true, the project can be utilized in museums to reduce the cost and increase the efficiency of preserving the old paintings without using any invasive methods. The main problem while preparing the experiment was setting up the ZnO ALD condition for the ink on a commercial paper and measuring the concentration of the ink that has been seeped out from the layer. Since the ink start to decompose if exposed to high temperature for prolonged time, lower temperature should be adapted for the ALD which gives longer deposition time. Plus, since only harvesting the ink that has been seeped out from the layer is virtually impossible, assuming the layer deposited is not degrading in the water, the paper was set in the water to create a solution and to be tested on the UV spectrometer. The obtained data was taken under the assumption that the any chemical reaction or decomposing rate of the paper in the distilled water is negligible and ZnO thin layer degradation in the water is negligible.

Methods

In this experiment, ten different blue ink-water solution types differed by 0.1% volumetric concentration were prepared. Samples were prepared by adding blue ink to 1mL of distilled water in the 1mL plastic vial. Three identical solution were prepared for each concentration and was mixed by mild shaking to achieve homogeneity. The minimum concentration was set to 0.1% for the samples with less than 0.1% concentration were failed to detect by UV spectrometer. All sample were then transferred to crystal cuvet and tested its absorbance in 300nm to 1000nm wavelength range using UV spectrometer. Knowing that blue light
wavelength range, peak at 381nm was chosen to be first peak of interest. Also, since the peak in 600nm showed strong correlation to the concentration of the sample, it was also taken as the second peak of interest. For more details on the actual data, Table I gives averaged individual absorbance of the peaks of interest.

Table I.

	0.1%	0.2%	0.3%	0.4%	0.5%	0.6%	0.7%	0.8%	0.9%	1.0%
600nm	0.0473	0.4757	0.9633	1.678	2.246	2.413	2.571	2.639	2.718	2.707
381nm	0.0397	0.0693	0.1	0.154	0.127	0.151	0.1736	0.1973	0.2467	0.323

Each peak of interest's data was plotted simultaneously using Microsoft Excel and analyzed using Beer-Lambert law as shown in Fig. 1.

Results

As shown in Fig. 2, the peak of interest at 600 nm wavelength shows plateau as the concentration reaches and passes 0.8% volumetric concentration. While at 381nm, the peak does not show significance until it reaches 0.5% volumetric concentration.

Fig 2. Absorbance vs wavelength plot from 500nm to 700nm (top) and from 340nm to 500nm (bottom)

The linearized plot for 600nm shows good linearity until it reaches 0.5% while for 381nm shows good linearity from 0.5% to 0.8% as shown in Fig. 1.

Discussion

From Fig 2. We can see that the plateau peak is gradually starting to form at 600nm as the concentration increases and it fully develops plateau after 0.8% volumetric concentration. This might have been caused for the Beer-Lambert law's linearity can be compromised when tested on high concentration. Thus, despite the peak at 600nm is the most distinctive peak, the data cannot be used as a control data in high concentration. On the contrary, at 381nm peak, as shown in Fig 2, the peaks become more distinctive as it reaches 0.5% or higher volumetric concentration. In addition, from Fig 1. linearized plot for 600nm peak loses its linearity after 0.5% volumetric concentration while plot for 381nm gains linearity after 0.5% volumetric concentration. Hence, the concentration less than 0.5% should be governed by peak at 600nm while concentration more than 0.5% should be governed by peak at 381nm when analyzing the experimental data of the ZnO coated sample. In addition, it was noticed that the UV spectrometer fails to discriminate any samples under 0.1% volumetric concentration and distilled water. Thus, 0.1%, which was the minimum concentration that showed viable peak, is set to be minimum concentration for control data. More chemically detailed analysis regarding the molecules present in the solution is scheduled to be conducted via Raman spectroscopy.