The Performance of Structural Coloration Fabricated by EHD Jet Printing

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1. Introduction

A Morpho butterfly doesn't have blue pigment, but show blue color. The reason for this is consist of a regular arrangement of the wedge-shaped structures[1]. It is called a structural coloration to express color without depending on chemical dye or pigment. The principle is that the repetitive microstructure with constant period, at the wavelength level of the light, causes constructive interference for specific wavelengths and destructive interference for the remaining wavelengths[2-4], so that only a specific wavelength of light is reflected. As long as the structure is maintained, these color don't cause decolourization and changed color. Also, when comparing the existing dyes and pigments, the eco-friendly material is used for the structural coloration development[5].

The method of manufacturing repetitive microstructures of structural coloration is classified two large groups in top-down and bottom-up. Top-down is a method of trimming from the surface of bulk-like crystals to a desired crystal structure[6]. However, this method requires a high-precision etching tool and has limitation in reducing the fine structure interval. On the other hand, bottom-up is a method of fabricating microstructures by laminating nanoparticles into a regular lattice structure using self-assembly technology[7]. This method is very economical and has the advantage of reducing the size of the structure interval to a nanometer level. However, frequently defects occur and it is difficult to fabricate the particles at the desired position, so much research is needed to overcome them.

In this work, the structural coloration was fabricated using EHD jet printing technology which minimizes the disadvantages of the bottom-up, and the spherical silica nanoparticles were prepared by the sol-gel method.

2. Spherical silica nanoparticle

The spherical silica nanoparticle were prepared by sol-gel process. In the manufacturing process, 40 ml of DI water and 50 ml of ethanol are mixed in a round flask. After put in 20 ml of tetraethyl orthosilicate, 6 ml of ammonia water is added and reacted sufficiently[8]. Finally, to remove unreacted solution, the water bath was heated to 60 ~ 65 ℃ for 2 days.

3. EHD jet printing

The principle of EHD(electrohydrodynamic) jet printing technology is to apply a voltage between the meniscus generated in the nozzle tip and the substrate to form an electric field. When, the sum of the electrostatic force and the gravity becomes larger than the surface tension of the liquid, so that the shape of the Taylor cone is formed, and the droplet is ejected from the cone tip portion to produce nano/micro-level patterning[9]. Fig. 1 is a schematic diagram of EHD jet printing.

The EHD jet printing setup varies greatly depending on the electrical conductivity of the solvent, the particles size and the viscosity. Therefore, in this work, the distance between the substrate and the nozzle was 3000 ~ 3500 μm, the printing speed was 150 ~ 400 mm/s, and the voltage was 2.5 ~ 2.8 kV.

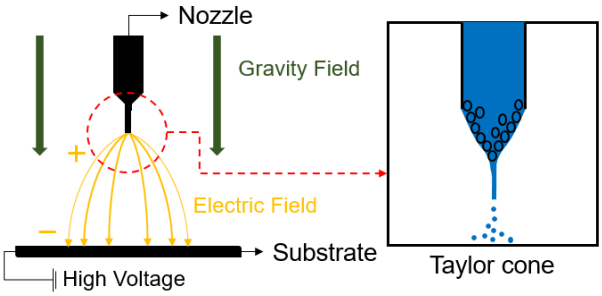

Fig. 1 Schematic diagram of EHD jet printing

4. Structural coloration

Fig. 2 (a) shows the structural coloration produced by EHD jet printing and color change from 0 to 10, 20, 30 and 40 degrees from the left. When the angle of (a) was 0 degree and 10 degree, the wavelength range of 450 ~ 500 nm appeared, and when the angle was 20, 30 and 40, the wavelength range of 500 ~ 700 nm appeared. Fig. 2 (b) shows the structural coloration produced by simple dipping. (b) was about 450 nm at 0 °, 450 ~ 550 nm at 10 °, 500 ~ 650 nm at 20 ° and 30 °, and a wavelength band of 550 ~ 700 nm at 40 °. Structural coloration produced by EHD jet printing and the structural coloration produced by dipping were observed to have a color spectrum of 450 ~ 700 nm as a whole. The structural coloration produced by dipping was found to have few defects, but the structural coloration produced by EHD jet printing was found to be defective due to unstable

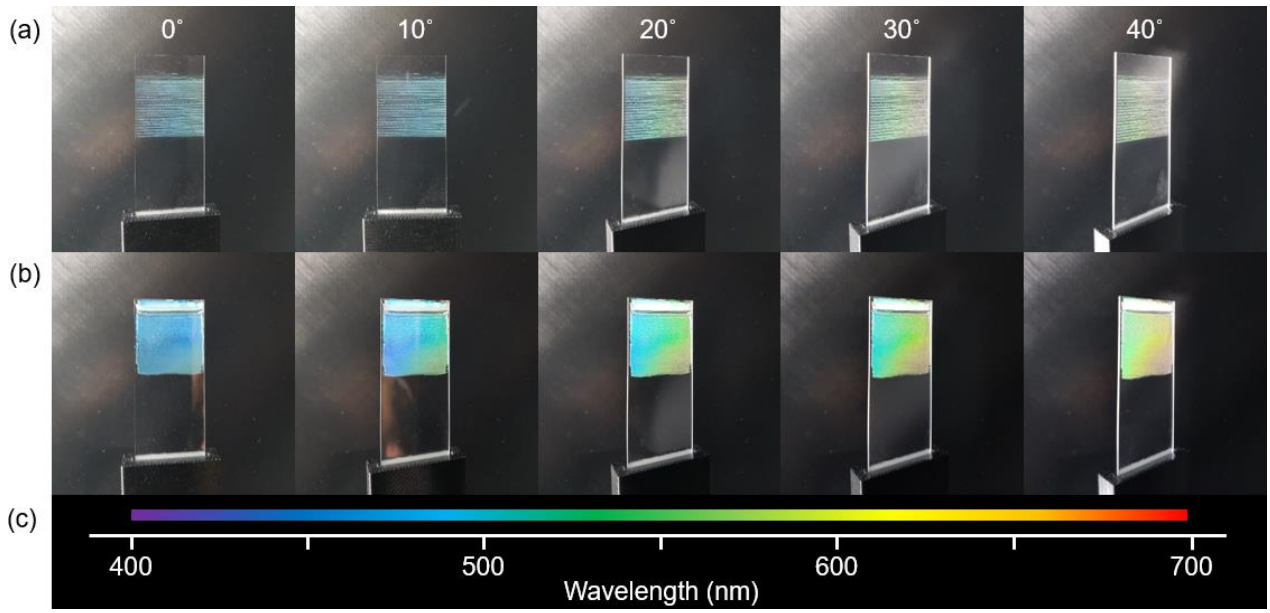

Fig. 2 Optical image of the structural coloration by angle change

jetting. The structural coloration produced by EHD jet printing showed the same color change at the top and bottom, but the color change of the structural coloration produced by dipping showed the difference of color change at the top and bottom. As a result, if stable jetting is possible, it is expected that there will be no defects and the same structural coloration can be produced in the upper and lower color changes.

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