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2 **Michael Addition Reaction-Assisted Surface Modification of Melanin Particles for**  
3 **Water-Repellent Structural Color Coating**  
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42 **Keywords:** Structural Color; Particles; Hydrophobic; Water-Repellent Coating; Surface  
43 Modification.  
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49 **Abstract**

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51 There is significant interest in developing paints based on structural colors, which do not  
52 fade like dyes and pigments. To use these paints as coatings, it is necessary to have a  
53 technology that can easily impart structural color to the material's surface without  
54 changing color based on the viewing angle. In addition, water-repellent properties that  
55 lead to stain resistance are required for practical application. In this study, we applied a  
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2 structural color coating by synthesizing hydrophobic melanin particles using the Michael  
3 addition reaction and arranging these particles on a substrate at high speed. The resulting  
4 coating film showed angle-independent structural color due to the amorphous structure  
5 of the particle arrangement, and the color tone could be controlled by adjusting the  
6 particle size. The combination of the particle's hydrophobic surface and the microscopic  
7 unevenness from the arrangement structure produced a superhydrophobic coating with a  
8 contact angle of over 160°. Since the Lotus effect, resulting from superhydrophobic  
9 surfaces, can maintain the cleanliness of structural color coatings, the findings of this  
10 research will contribute to the development of next-generation coating technology.  
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## 21 **1. Introduction**

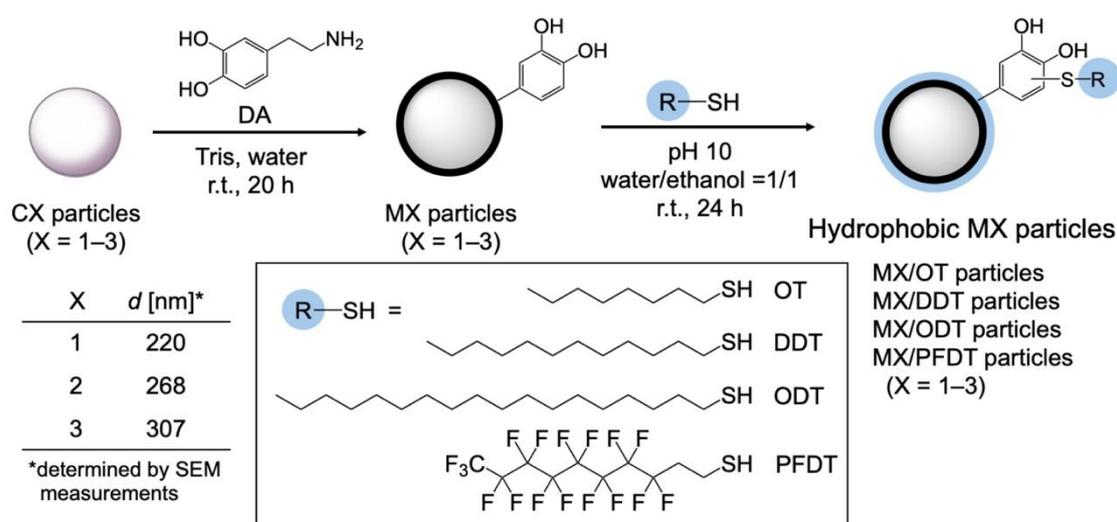
22 Paints based on dyes and pigments are widely used to color products across various  
23 industries and play an essential role in everyday life. However, these paints—especially  
24 those containing organic molecules—have the fundamental problem of fading easily due  
25 to light or aging. Structural color is created by the interference of visible light with  
26 periodic microstructures and has been utilized in art since ancient times.<sup>[1]</sup> Recently,  
27 coating technologies that utilize structural color have gained attention as next-generation  
28 alternatives because, unlike dyes and pigments, structural colors do not fade.<sup>[2]</sup> Various  
29 periodic structures, such as thin-film interference, multilayer interference, diffraction, and  
30 scattering, can produce structural colors, and materials have been developed to take  
31 advantage of the characteristics of each of these optical phenomenon.<sup>[3]</sup> From the  
32 viewpoint of fabricating artificial structural color materials, it is important to design  
33 materials that incorporate these microstructures.<sup>[4]</sup>  
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44 Structural colors derived from particle arrangement structures have been the subject of  
45 much research, as the color tone can be easily adjusted by changing the size of the  
46 particles.<sup>[5]</sup> Colloidal crystals, in which colloidal particles are arranged regularly, have  
47 the attractive property of exhibiting angle-dependent structural color based on long-range  
48 ordered periodic structures. Research using colloidal crystals is thus being actively  
49 conducted.<sup>[6]</sup> For coating applications, it is preferable to use structural colors, which  
50 maintain a consistent color tone regardless of the viewing angle. Structural color materials  
51 with low angle dependence have been inspired by the coloring mechanisms of organisms  
52 that exhibit non-iridescent structural color.<sup>[7]</sup> In amorphous states, where particle  
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2 arrangement regularity is reduced, Bragg diffraction is suppressed, leading to angle-  
3 independent structural color based on short-range order.<sup>[8]</sup> Besides controlling the degree  
4 of particle arrangement, particle composition is also an important factor in determining  
5 the characteristics of structural color materials. Melanin is well known as a microstructure  
6 component that produces the vivid structural colors observed in various organisms.<sup>[9]</sup> Our  
7 research focuses on biomimetic, melanin-based structural color materials by creating and  
8 assembling particles containing polydopamine (PDA), an artificial melanin.<sup>[10]</sup> Core-  
9 shell-type melanin particles, where the surface of a core particle is coated with PDA,  
10 exhibit light absorption characteristics in the visible range, suppress multiple scattering,  
11 and produce vivid structural colors.<sup>[11]</sup>

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13 In the development of paints based on structural color, it is necessary to impart water-  
14 repellency to the paint film, which gives it a self-cleaning effect and stain-resistant  
15 properties. Surface modification using fluorine molecules is generally effective for  
16 creating water-repellent surfaces. For example, Sun et al. obtained a water-repellent  
17 structural color film by spraying a fluorine compound onto the surface of a pre-prepared  
18 particle array.<sup>[12]</sup> While this technique is useful, there is increasing demand for fluorine-  
19 free water-repellent coatings due to concerns about their impact on the environment and  
20 human health. Another common method for achieving water repellency is surface  
21 modification using polydimethylsiloxane (PDMS). Coating particle arrays with PDMS  
22 creates a water-repellent surface; however, this process is often complex and requires  
23 multiple steps.<sup>[13]</sup> The *Morpho* butterfly is a well-known example of an organism that  
24 combines structural coloration with water repellency.<sup>[14]</sup> The microscopic structures  
25 inside the ground scales on the wings of *Morpho* butterflies produce a blue structural  
26 color, while the water-repellent properties come from the microscopic structure on the  
27 surface of the cover scales, which prevents the wings from getting wet.<sup>[15]</sup> On  
28 superhydrophobic surfaces with a contact angle exceeding 160°, water droplets form a  
29 sphere, which minimizes the solid–liquid interface area, making it easy for dust and dirt  
30 to adhere to the surface of the water droplet. As a result, the surface is kept clean; this  
31 phenomenon is known as the “Lotus effect”.<sup>[16]</sup> Developing a simple method to create  
32 materials with both structural color and water-repellency by leveraging the microstructure  
33 of the material’s interior and surface is an important goal in next-generation paint  
34 development.

In this study, we investigated the development of a coating technology that imparts both water-repellency and angle-independent structural color in a single process by rapidly arranging surface-modified melanin particles. One of the advantages of PDA is its ease of post-modification: molecules and polymers containing amine or thiol groups can be introduced into the PDA layer via Michael addition and Schiff base reactions.<sup>[17]</sup> Hydrophobic melanin particles were prepared by surface modification of the PDA layer with hydrophobic molecules containing thiol groups using a Michael addition reaction (Figure 1). Monodisperse crosslinked polystyrene particles of three different diameters were prepared, designated as CX particles (X=1–3). A thin shell layer of PDA (i.e., a melanin layer) was coated onto the CX particles via oxidative polymerization of dopamine (DA) to obtain MX particles. Hydrophobic molecules—1-octanthiol (OT), 1-dodecanthiol (DDT), 1-octadecanthiol (ODT), and 1H,1H,2H,2H-perfluorodecanthiol (PFDT)—were introduced into the PDA layer on the MX particle surface through Michael addition reactions, resulting in MX/OT, MX/DDT, MX/ODT, and MX/PFDT particles, respectively. Detailed experiments were performed to assess the hydrophobicity and structural color properties of the fabricated hydrophobic MX particles. We successfully imparted water-repellency to the MX particles without using fluorine molecules, and we investigated the potential use of these particles as water-repellent structural color paints.



**Figure 1.** Scheme for the preparation of CX, MX, and hydrophobic MX particles.

## 2. Experimental Section

### 2.1. Materials

Dopamine hydrochloride (DA) was obtained from Sigma–Aldrich Japan Co., LLC (Tokyo, Japan). Styrene (St), 2,2'-azobis(2-amidinopropane)dihydrochloride (V-50), and tris(hydroxymethyl)aminomethane (Tris) were obtained from Kanto Chemical Co., Inc. (Tokyo, Japan). *p*-Divinylbenzene (DVB), 1-octanethiol (OT), 1-dodecanethiol (DDT), 1-octadecanethiol (ODT), and 1H,1H,2H,2H-perfluorodecane-1-thiol (PFDT) were obtained from Tokyo Chemical Industry (Tokyo, Japan). A Millipore Simplicity UV system provided deionized water with an 18.2 M $\Omega$ ·cm resistance. St and DVB were dried over calcium hydride and distilled under reduced pressure before use. *N*-Butyl-*N*-2-methacryloyloxyethyl-*N,N*-dimethylammonium bromide (C<sub>4</sub>DMAEMA) was synthesized according to the previous report.<sup>[18]</sup> All other chemicals and solvents were reagent grade and used as received. Melamine resin boards were purchased from Standard Testpiece Co. (Kanagawa, Japan).

### 2.2. Measurements

Infrared absorption spectra were obtained using an attenuated total reflection Fourier transform infrared (ATR-FTIR) spectrometer (FT/IR 4700; JASCO). X-ray photoelectron spectroscopy (XPS) measurements were carried out using a photoelectron spectrometer (JPS-9030; JEOL). Contact angles were measured using a contact angle meter (DMs-401; Kyowa Interface Science). Time-domain nuclear magnetic resonance (TD-NMR) measurements were performed with a low-field NMR system (MagnoMeter XRS; Mageleka). Scanning electron microscopy (SEM) images were obtained using a scanning electron microscope (JSM-6510A; JEOL). Transmission electron microscopy (TEM) images were obtained using a transmission electron microscope (H-7650; Hitachi). Optical microscopy images were obtained with a digital microscope (VHX-X1F; Keyence). Reflection spectroscopy was obtained using a microscopic spectrophotometer (MSV-370; JASCO). Photographs and movies of the samples were taken with a digital camera (OM-D E-M10; Olympus, EXILIM EX-100F; CASIO, iPhone15 pro; Apple). Particle purification was conducted using a centrifuge (Suprema 21; TOMY).

### 2.3. Preparation of MX particles

MX particles (melanin particles) were prepared as described in our previous paper.<sup>[19]</sup> Briefly, CX particles were synthesized by emulsifier-free emulsion polymerization using St (8.33 g, 80 mmol), DVB (0.21 g, 1.6 mmol), and water (80 mL) in the presence of V-50 (initiator, 0.33 g, 0.80 mmol). The particle size was controlled by adding C<sub>4</sub>DMAEMA (hydrophilic monomer, 37.8–40.0 mg, 0.13–0.14 mmol). The resulting P(St-DVB) core particles (1.20 g), DA (0.60 g, 3.20 mmol), and Tris (14.5 g, 120 mmol) were dispersed in deionized water (1.20 L) and stirred for 20 h at room temperature. The resulting samples were separated and purified repeatedly by centrifugation (12,000 rpm for 30 min) and redispersion to obtain MX particles. The average particle diameter and coefficient of variation (CV) were determined from 100 particles observed in SEM images. The PDA shell layer thickness of the samples was calculated using the following Formula (1):<sup>[20]</sup>

$$\text{PDA shell thickness} = \frac{(\text{diameter of MX particles}) - (\text{diameter of CX particles})}{2} \quad (1)$$

### 2.4. Preparation of hydrophobic MX particles

Hydrophobic MX particles were prepared by modification using a Michael addition reaction, in which thiol-terminated molecules (OT, DDT, ODT, and PFDT) were introduced into the catechol/quinone groups of the PDA shell layer on the particle surface. MX particles (0.24 g), Tris (1.45 g, 12 mmol), and thiol-terminated molecules (0.24–4.8 mmol) were dispersed in 240 mL of a water/ethanol mixed solvent (1/1) and stirred at room temperature. After 24 h, the particles were purified through repeated centrifugation (12,000 rpm for 30 min) and redispersion to yield hydrophobic MX particles (MX/OT, MX/DDT, MX/ODT, and MX/PFDT).

### 2.5. Water-repellent structural color coating with hydrophobic MX particles

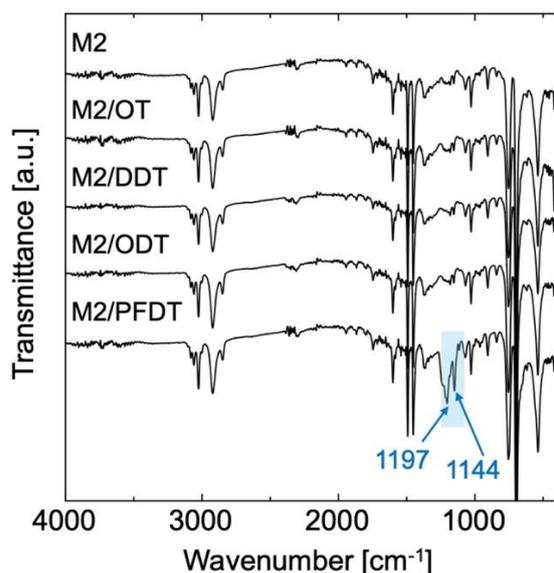
M3/ODT particles dispersed in hexane (3 wt%) were used as the coating material. The prepared M3/ODT particle dispersion was applied to commercially available melamine resin board (5 × 5 cm) using a brush to form a structural color coating.

### 3. Results and discussion

#### 3.1. Michael addition reaction-assisted preparation of hydrophobic MX particles

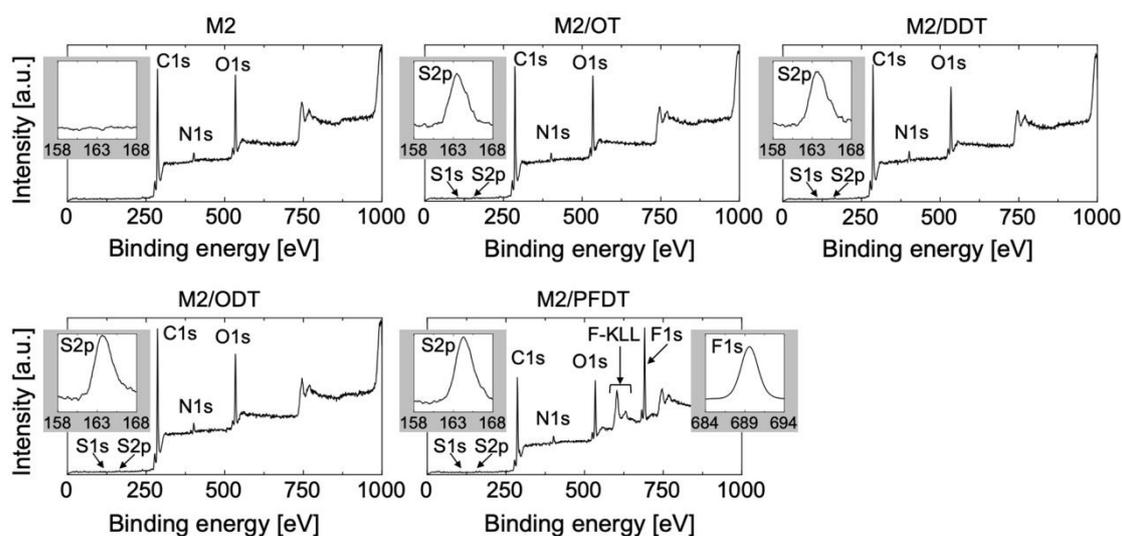
CX particles ( $X = 1-3$ ) with average particle sizes of 220, 268, and 307 nm, as measured by SEM, were prepared via emulsifier-free emulsion polymerization of St and DVB (Figure S1a). DA polymerization was then carried out on the surface of the CX particles to obtain MX particles ( $X = 1-3$ ) with a PDA shell layer approximately 5 nm thick (Figure S1b). A vivid structural color was observed in the MX particle pellets coated with a melanin layer, while the pellet samples obtained from naturally dried CX particles appeared milky white due to multiple scattering of light (Figure S1 insets).<sup>[21]</sup> The reflection wavelengths of the pellet samples prepared with MX particles shifted to longer wavelengths due to their larger particle size compared to those of the samples prepared with CX particles: approximately 501, 572, and 655 nm, respectively. As a result, the structural colors of blue, orange, and red were observed (Figure S2).

Hydrophobic molecules containing terminal thiol groups were introduced onto the surface of the melanin particles using the Michael addition reaction. The hydrophobic molecules used were OT, DDT, and ODT, each with alkyl groups of different lengths. As a comparison, PFDT, a fluorine compound, was also used (Figure 1). TEM observations of the resulting hydrophobic M2 particles showed no significant differences compared to the unmodified M2 particles before modification due to the small size of the hydrophobic molecules (Figure S3). We evaluated the hydrophobic M2 particles using ATR-IR measurements (Figure 2). Unfortunately, in the spectra of the hydrophobic M2 particles, the peaks derived from the alkyl groups overlapped with the peaks of the M2 particles. Therefore, the introduction of the alkyl chains could not be confirmed through IR measurements. In contrast, strong absorption bands at 1144 and 1197  $\text{cm}^{-1}$  were observed in the spectra of the M2/PFDT particles due to the stretching vibrations of C-F groups in PFDT, indicating that the particle surface was modified with PFDT.



**Figure 2.** ATR-IR spectra of M2 and hydrophobic M2 particles.

The presence of sulfur atoms on the particle surfaces was investigated by XPS measurements, as the hydrophobic molecules introduced via the Michael addition reaction contained thiol groups (Figure 3). No S2p signal was observed in the XPS spectrum of the unmodified M2 particles. In contrast, clear S2p signals were observed in the XPS spectra of the M2/OT, M2/DDT, M2/ODT, and M2/PFDT particles, indicating that hydrophobic molecules with thiol end groups were introduced into the PDA shell layer by Michael addition reactions. Additionally, the F1s and F-KLL peaks observed in the spectrum of the M2/PFDT particles further indicated the presence of fluorine atoms on the particle surface.



**Figure 3.** XPS spectra of M2 and hydrophobic M2 particles.

### 3.2. Effect of the modified molecules on the hydrophobicity of MX particles

Solvents in contact with or adsorbed on the particle surface and free-state bulk solvents respond differently to changes in the magnetic field: the proton relaxation time of bulk solvents is longer, while that of solvents constrained to the particle surface is shorter (Figure 4a).<sup>[22]</sup> The spin relaxation rate constant  $R_n$  is determined from the reciprocal of the spin relaxation time  $T_n$  and is expressed by the following Equation (2):<sup>[23]</sup>

$$R_n = \frac{1}{T_n} \quad (2)$$

While the relaxation time is a fundamental measurement, the relaxation number  $R_{no}$  is a value that is a practical metric for various applications.  $R_{no}$  is a dimensionless parameter expressed by the following Equation (3):<sup>[23]</sup>

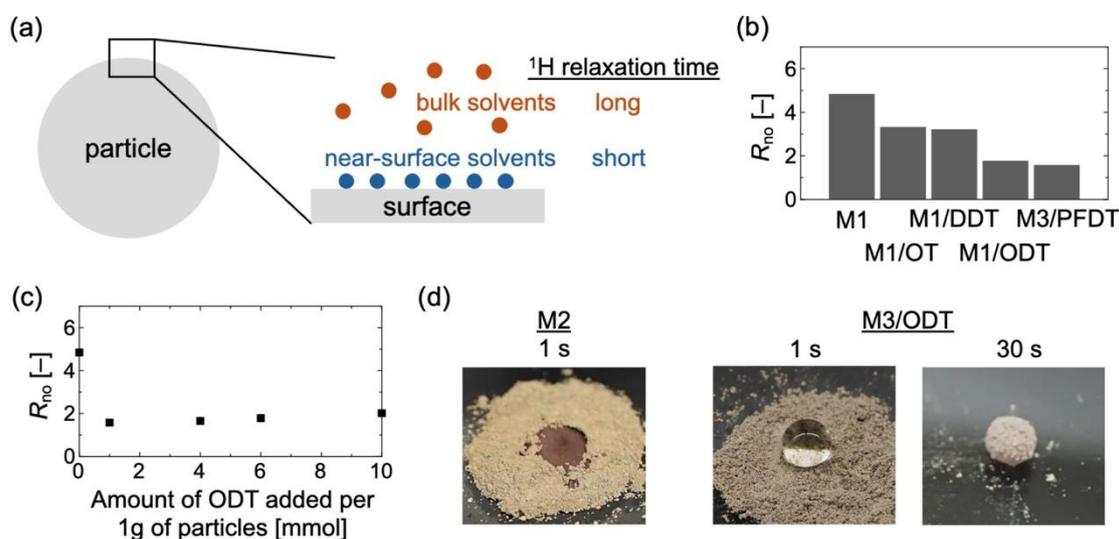
$$R_{no} = \frac{R_{susp} - R_{solv}}{R_{solv}} = \frac{R_{susp}}{R_{solv}} - 1 \quad (3)$$

where  $R_{susp}$  and  $R_{solv}$  are the relaxation rates of the suspension and its (bulk) dispersion solvent, respectively. In this study, ethanol was used as the solvent because the fabricated hydrophobic MX particles dispersed well in it. The proton spin–spin relaxation time ( $T_2$ ) of the particle-dispersed ethanol solution was measured using TD-NMR. Rearranging the

formula,  $R_{no}$  becomes the following Equation (4):

$$R_{no} = \frac{T_{2solv}}{T_{2susp}} - 1 \quad (4)$$

where  $T_{2susp}$  and  $T_{2solv}$  are the spin–spin relaxation time of the protons of the suspension and its dispersion solvent (ethanol), respectively. Figure 4b shows the  $R_{no}$  values for each hydrophobic MX particle, prepared with a constant hydrophobic molecule feed ratio (4 mmol to 1 g of the particles). The bare M1 particles have a high  $R_{no}$  value of approximately 4.8, indicating that the PDA shell layer with many hydroxyl groups is well-wetted by ethanol. The  $R_{no}$  values for M1/OT, M1/DDT, and M1/ODT particles decreased as the alkyl chain length of the introduced hydrophobic molecules increased. This indicates that modifying the MX particle surface with hydrophobic molecules reduced the wettability of the particles to ethanol, meaning increased hydrophobicity.<sup>[24]</sup> Notably, the  $R_{no}$  values for the M1/ODT particles were almost equal to those of M3/PFDT particles with PFDT, known to exhibit high water repellency. Figure 4c shows the  $R_{no}$  values for M1/ODT particles prepared with varying ODT feed ratios. The  $R_{no}$  values remained around 1.5, regardless of the ODT feed ratio, under the conditions of the present experiment. As a result, subsequent experiments utilized MX/ODT particles (ODT feed ratio: 4 mmol to 1 g), which exhibited high hydrophobicity without requiring fluorine compounds.

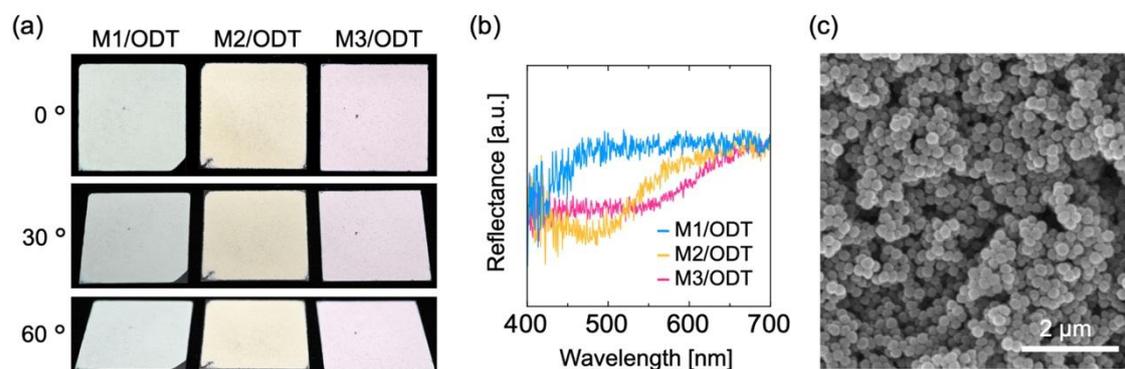


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2 **Figure 4.** (a) Schematic diagram of the bulk and near-surface solvents. (b)  $R_{no}$  values of  
3 the obtained particles. The concentration of the particles in the dispersion was set to a  
4 constant value (3 wt%) and measured. (c)  $R_{no}$  values of the M1/ODT particles prepared  
5 by varying the amount of ODT added. (d) Photographs of M2 (left) and M3/ODT (center)  
6 particle powders one second after the water droplet was dropped. A photograph of a liquid  
7 marble obtained after shaking a substrate coated with M3/ODT powder by hand for 30 s  
8 to roll the water droplets (right).  
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18 The wettability of MX/ODT particles in water was investigated by dropping 20  $\mu\text{L}$  of  
19 water onto a powder prepared from dried and ground M2 or M3/ODT particles. As shown  
20 in Figure 4d, M2 powder absorbed the water droplets instantly, causing the entire surface  
21 to become wet, indicating high hydrophilicity. In contrast, on the M3/ODT powder, the  
22 water droplets retained a spherical shape, demonstrating that the particles had become  
23 hydrophobic. The clock glass with M3/ODT powder was shaken by hand for  
24 approximately 30 s to roll the water droplets (Movie S1). This resulted in the formation  
25 of a stable water droplet with particles adsorbed on the surface (liquid marbles).<sup>[25]</sup> This  
26 result is consistent with previous studies showing that particles with hydrophobic surfaces  
27 tend to form liquid marbles.<sup>[26]</sup>  
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### 38 **3.3. Water-repellent structural color coating**

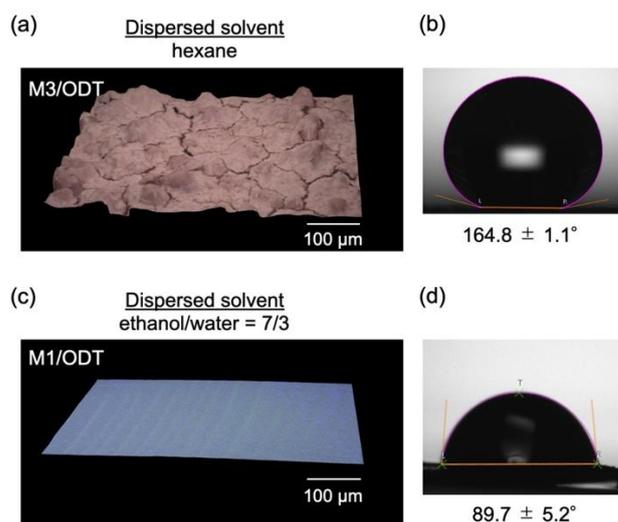
39 By utilizing hexane as a solvent, with its low boiling point of 69 °C, it was possible to  
40 obtain structural color films within a short time of approximately 1 minute, which is an  
41 important advantage when considering practicality (Figure 5a). By changing the particle  
42 size used, the structural color of the film was adjusted. Peaks corresponding to the  
43 wavelengths of each color appeared in the reflection spectra of the films (Figure 5b). SEM  
44 image of the structural color coating surface revealed an amorphous arrangement of the  
45 particles (Figure 5c). In the case of a particle-arrayed film with an amorphous structure,  
46 no long-range periodic structure is formed.<sup>[27]</sup> As a result, a certain structural color was  
47 shown irrespective of the observation angle, as shown in Figure 5a.  
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**Figure 5.** (a) Photographs of samples obtained by dropping and drying hydrophobic MX/ODT particles (3 wt%, 150  $\mu$ L) dispersed in hexane onto a glass substrate ( $18 \times 18$  mm). The numbers in the figure indicate the shooting angle. (b) Reflectance spectra of the samples shown in (a). (c) SEM image of the surface of the M1/ODT coating film.

The surface of the structural color coating created was evaluated using the 3D imaging function of a digital microscope. The sample shown in Figure 5a was prepared using M3/ODT particles dispersed in hexane, and its surface had micron-sized irregularities (Figures 6a and S4). The contact angle measurement of the coating film was  $164.8 \pm 1.1^\circ$ , indicating that the surface possessed superhydrophobic properties (Figure 6b).<sup>[28]</sup> The contact angles of the surface of the structural color coating made from M1/ODT and M2/ODT particles dispersed in hexane also showed superhydrophobicity, with contact angles exceeding  $160^\circ$  (Figure S5). The regularity of the particle arrangement varied greatly depending on the dispersion solvent. When an ethanol/water mixture is used as a dispersed solvent, the surface tension of the solvent decreased, leading to a smoother surface in the resulting particle arrangement structure.<sup>[29]</sup> Therefore, we dropped M1/ODT particles, which had been dispersed in a 7/3 ethanol/water mixture, onto a substrate, dried them, and observed the surface of the resulting film under a digital microscope. As shown in Figure 6c, a smooth surface was obtained even though the same hydrophobized MX particles were used, by changing the dispersed solvent. The contact angle of this surface was approximately  $90^\circ$  (Figure 6d). These results indicate that it is impossible to obtain a superhydrophobic coating by simply modifying the surface of the MX particles with hydrophobic molecules. In addition to modifying the particle surface

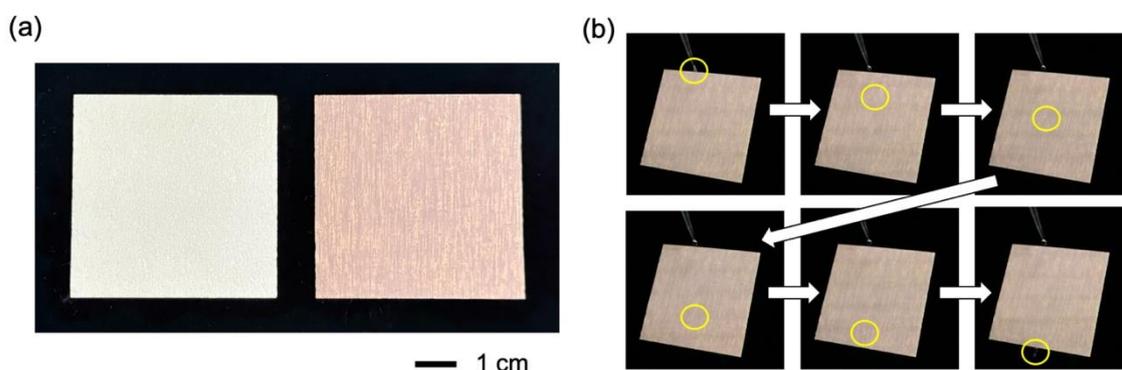
with alkyl groups, the formation of a hierarchical structure with a moderately disordered particle arrangement structure made it possible to create a superhydrophobic structural color coating.



**Figure 6.** (a) Digital microscope image and (b) contact angle of the coating film made using M3/ODT particles dispersed in hexane. A 12 μL water droplet was dropped and the contact angle was measured using the Young–Laplace method. (c) Digital microscope image and (d) contact angle of the coating film made with M1/ODT particles dispersed in an ethanol/water (7/3) mixed solvent. A 2 μL water droplet was added, and the contact angle was measured via the Young method.

Finally, the structural color paint was applied to the surface of a commercially available melamine resin board (commonly used for exterior walls) using a brush. Initially, the melamine resin board had a white surface Figure 7a (left). Upon applying the M3/ODT particle solution dispersed in hexane, a red structural color was observed (Figure 7a (right)). The melamine resin board was then propped up, and a water droplet was dropped on it from above. This was photographed with a high-speed camera. As shown in Figure 7b and Movie S2, the water droplet rolled down the surface of the structural color coating, leaving no noticeable change on the surface of the coating. This is due to the Lotus effect mentioned above, in which dirt and dust are removed along with water droplets on superhydrophobic surfaces. This demonstration shows that it is possible to successfully

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2 impart these two characteristics to the surface of a material: structural color and  
3 hydrophobicity.  
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22 **Figure 7.** (a) Photographs of a bare melamine resin board (left) and a melamine resin  
23 board coated with structural color paint (right). (b) High-speed camera images of a drop  
24 of water on the surface of a melamine resin board coated with structural color paint. The  
25 yellow circles in the images show the position of the drop of water.  
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#### 32 **4. Conclusion**

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34 Hydrophobic molecules containing thiol groups were successfully introduced onto the  
35 surface of melanin particles via a Michael addition reaction. The hydrophobicity of the  
36 particles varied based on the alkyl group length of the hydrophobic molecules, and the  
37 degree of hydrophobicity was assessed using TD-NMR measurements. Notably, ODT-  
38 modified particles showed a high level of hydrophobicity equivalent to that of the  
39 particles with fluorine molecules, despite the absence of fluorine. The hydrophobic  
40 surface of the MX/ODT particles improved their dispersion in organic solvents. By  
41 coating a substrate with MX/ODT particles dispersed in a low-boiling-point solvent, a  
42 particle array structure rapidly formed on the substrate surface, resulting in a highly  
43 visible, angle-independent structural color coating film derived from melanin particles.  
44 This structural color coating showed superhydrophobicity of over  $160^\circ$  due to the  
45 combined effects of the chemical hydrophobicity of the particle surface and the physical  
46 unevenness of the particle arrangement. The Lotus effect, in which water droplets roll off  
47 the surface, was observed on the superhydrophobic structural color coating, so it is  
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2 expected to be effective in preventing dirt adhesion. Since the structural color will not  
3 fade as long as the microscopic structure is intact, these findings will lead to the  
4 development of next-generation paints.  
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### 9 **Supporting Information**

10 Supporting Information is available from the Wiley Online Library or from the author.  
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18 her assistance with the experiments. The XPS measurements were performed at the  
19 Center for Analytical Instrumentation and the Chiba Iodine Resource Innovation Center  
20 (CIRIC), Chiba University.  
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33 Published online: ((will be filled in by the editorial staff))  
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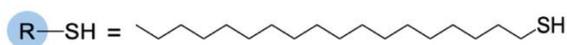
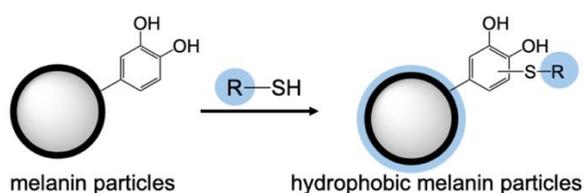
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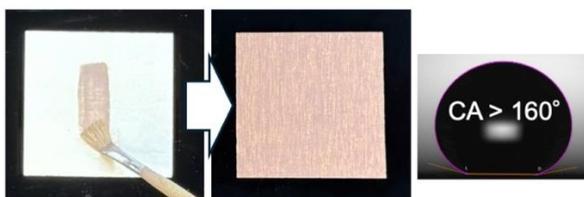
A coating technology has been developed that uses hydrophobic melanin particles to impart angle-independent structural color on material surfaces. The contact angle of the resulting structural color coating film exceeds 160°, forming a superhydrophobic surface.

Yui Maejima, Mana Tomizawa, Ai Takabatake, Shin-ichi Takeda, Hiroshi Fudouzi, Keiki Kishikawa, and Michinari Kohri\*

### Michael Addition Reaction-Assisted Surface Modification of Melanin Particles for Water-Repellent Structural Color Coating

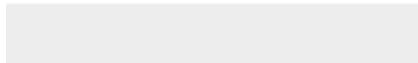


water-repellent structural color coating



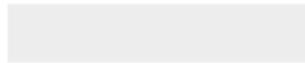


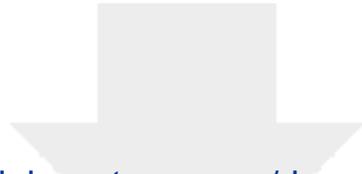
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