Selection 1  Material Science

**Structural and Physical Properties of Liquid Marble**

Pressure-sensitive adhesive (PSA) powder consists of particles with a soft adhesive polymer core and a hard particle shell morphology that shows no adhesion and flows like a powder in its original form. Droplets stabilized by adsorbing solid particles on its surface are termed as liquid marbles. Only after application of shear stress, does PSA show its adhesive nature. Adhesion is induced by rupture of the nanoparticle coating of the powder and outflow of the inner soft polymer. We investigated the structural and adhesive properties using a Nano Search® microscope, an electron probe microanalyzer (EPMA), a microfocus X-ray CT system, and a probe tack tester.

Selection 2  Material Science

**Preparation of Mimetic Materials of Shells and Their Properties**

Since the hardness and toughness of natural nacre are determined by hierarchical microstructures with organic matters, it is of great importance to control the microstructures of artificial free-standing CaCO₃ thin films. However, because the fabrication of such films has so far been quite limited, their mechanical properties have not been reported to a significant extent. To address this, free-standing calcite thin films were prepared through repeated cycles of layer-by-layer deposition of vaterite precursor composite particles with organic polymers, followed by a phase transition to calcite. The vaterite precursor composite particles were obtained by using a carboxylic-terminated poly(amidoamine) (PAMAM)-type 18-caged silesquioxane-core dendrimer (POSS-(COOH)₄₈) or an octacarboxy-terminated 18-caged silesquioxane (POSS-(COOH)₈). Incubation of the vaterite composite particles in distilled water for 3 days led to complete phase transition to calcite. Calcite thin films were obtained on a glass substrate pre-coated with a poly(diallyldimethylammonium chloride) (PDDA) layer or a multilayer of PDDA with poly(sodium 4-styrenesulfonate) (PSS) through repeated cycles of layer-by-layer deposition of the vaterite particles, followed by a phase transition to calcite. Free-standing calcite thin films were obtained through repeated cycles of this process after PDDA and PSS were coated on the surface of the calcite thin films. In this way, six distinct calcite thin film types were produced, with subsequent three-point bending tests revealing that all exhibit elastic bending prior to fracture.

Selection 3  Material Science

**Color Analysis of New Optical Film (MLF) with Super Multilayer Structure Based on the Incident Angle of Light**

Teijin DuPont Films Japan Limited has developed a new multilayer optical film (MLF) that has a super multilayer structure. This structure is designed to mimic the wing of a morpho butterfly, which creates color structurally. The key characteristics of structural coloration are that coloration varies according to the angle of view, and unlike pigments, the color does not fade because the color is produced due to its structure. In this paper, we describe using the SolidSpec-3700DUV spectrophotometer with a variable angle absolute reflectance attachment to perform measurements of a new multilayer optical film based on the incident angle of light. We confirmed that changing the incident angle of light to a MLF film changes the transmittance spectrum. In addition, using the L*a*b* color space to evaluate the transmittance spectrum, we were able to digitize the color and confirm the correlation between the visual color changes and the numerical values.

Selection 4  Material Science

**Fluorescence Measurement of Organic Electroluminescent Material**

Screens, lighting, and other products that incorporate organic electroluminescent (EL) materials are being developed on a daily basis in the electrical and electronic goods sector. Organic EL material development involves the synthesis of new substances and verification of their optical properties using photoluminescence (PL) technique. Researching the PL allows us to find materials that emit light with high efficiency, and we can elucidate the mechanism of its fluorescence in solution. Organic EL materials are developed through this process to meet specific criteria that can include hue, low energy consumption, or high luminous efficiency. In order to evaluate organic EL materials, fluorescence must be measured quickly and accurately over a wide range of wavelengths. Introduced here are the measurements of porphyrin solution (solvent: chloroform), an organic EL material, using an RF-6000 spectrofluorophotometer, with the help of the Institute for Basic Science, Pohang University of Science and Technology (POSTECH), South Korea.
Ultrasound Fatigue Testing of Metal Materials

Generally it is known that with most structural metal materials the fatigue strength lowers until a load is applied $10^6$ times, and from $10^6$ times onward the fatigue limit is reached, at which no fatigue fracture will occur. However, it is also revealed that with high-strength metal materials that are hardened or surface treated, internal inclusions become an origin of a fatigue fracture and cause a fracture even at $10^9$ to $10^{10}$ cycles. On the other hand, recently, the functionality and endurance required for industrial products are becoming stringent, and according to this trend, metal materials forming industrial products must also meet rigorous requirements. Therefore, conventional testing with a maximum of $10^6$ loading cycles is now insufficient, and a fatigue test exceeding $10^9$ cycles has become required. However, such a fatigue test will take considerable time. For example, a test with $10^9$ cycles at a frequency of 10 kHz theoretically requires about 3.2 years. The ultrasonic fatigue testing system used for this experiment enables testing at a frequency of 20 kHz, achieving a test with $10^9$ cycles in about 14 hours. Therefore, this testing system is a very effective measurement system for fatigue tests exceeding $10^9$ cycles.

In this experiment, we used two kinds of metal specimens, SNCM439 and A6063, for testing according to WES 1112: 2017 (Ultrasonic fatigue testing method for metal materials) stipulated by the Japan Welding Engineering Society. The results are introduced in this article.

Surface Analysis of PET Film Using a Benchtop MALDI-TOF Mass Spectrometer

MALDI-TOF mass spectrometers are a mass spectrometer type that is used in a wide range of fields likewise LCMS, in terms of high throughput and high sensitivity. These instruments have recently been utilized more and more for simple molecular weight measurement and profiling of synthesized products and high-molecular compounds. This is because instruments of this type have several features: singly-charged ions are generated so molecular weights can be recognized easily, the mass range is wide, and there are many solvent options because the sample is dried before measurement. On the other hand, due to changes in social conditions in these several years, government offices, universities, and private enterprises strongly request the reduction of costs for both introduction and running of instruments used for such applications. The benchtop “MALDI-8020” MALDI-TOF mass spectrometer is a new instrument that can sufficiently meet such market needs. The noteworthy point of this instrument is that it has a shorter flight tube, which is the key feature of its small size, while retaining the performance equal to or higher than that of a conventional model. In recent years, the usability of MS imaging using a MALDI-TOF mass spectrometer has become widely recognized and various techniques are being developed. On the other hand, needs for examining the compounds that exist on surfaces, rather than its “microscopic structure”, are increasing in association with degradation and durability tests. This article introduces an example of analyzing a PET film surface using the benchtop MALDI-TOF mass spectrometer “MALDI-8020”.

Evaluation of Photonic Materials with Biomimetic Structural Coloration

Colors occur either as pigments that absorb certain colors while reflecting/scattering others or as structural coloration caused by microscopic structures. Many living things in the natural world produce this type of structural coloration that results in vivid colors, including morpho butterflies, peacocks, and jewel beetles. Biomimetics is gaining attention as a field that utilizes the functions and structures of these things in the development of new technology and manufacturing processes by mimicking them. In Application News No. 4S02, we confirmed the existence of structural coloration on a multi-layered film produced by mimicking the wing structure of morpho butterflies, in which the coloration was caused by interference.1) The vivid colors observed on the wings of some birds are also structural coloration. For example, the structural coloration of peacock plumage is said to originate from the arrangement of melanin granules.2) Michinari Kohri, Associate Professor at the Division of Applied Chemistry and Biotechnology at Chiba University’s Graduate School of Engineering, has succeeded in producing highly visible structural coloration from the arrangement of melanin-mimicking particles (PSt@PDA particles) created by coating the surface of polystyrene particles (PS) with polydopamine (PDA), which is similar to melanin.3) This article introduces measurements of photonic materials with structural coloration performed in cooperation with Associate Professor Michinari Kohri.

X-ray Diffraction Analysis of Cement (2)
- Quantitative Analysis of Compounds Using the Rietveld Method -

Cement is manufactured through the processes of crushing and mixing raw materials, calcination, and finishing. The crushing and mixing process uses raw materials such as limestone, clay, silica stone, and iron oxide and these materials contain alite (C3S), belite (C2S), aluminate (C3A), and ferrite (C4AF). Since the ratios of these compounds differ according to manufacturer and product type and significantly affect product performance, cement is analyzed using X-ray fluorescence and X-ray diffraction. However, even with X-ray diffraction, which is capable of qualitatively analyzing powder samples, quantitative analysis of samples consisting of multiple components is known to be difficult due to considerable overlapping of diffraction lines. This article introduces an analysis example of a cement powder sample which is known the component composition and the ratio, using Siroquant software (Sietronics Pty. Ltd.) applying Rietveld analysis method which is the one of the profile fitting method. Siroquant enables identification of composition components and quantitative analysis in addition to the element analysis using X-ray fluorescence in quality control of cement.
Selection 9  Material Science

Quantitative Analysis of Lead in Bismuth Bronze - Matrix Elements/Profile Correction and Comparison with AA -

Some copper alloys are added with lead (Pb), but with the regulation of environmentally hazardous substances such as RoHS, it has been replaced by bismuth (Bi) in recent years. In X-ray fluorescence analysis, Bi interferes with Pb, that is, spectra overlap, so the quantitative accuracy of low content Pb may not be sufficient. In such cases, calibration curve method applying overlap correction by coexisting elements is effective. Metal samples are generally measured in the plane of cutting and polishing, but there are cases in which the samples are of irregular shapes such as chips and wiring. For irregularly shaped samples with coexisting elements, shape correction is required in addition to the overlap correction described above. This article introduces an examination of the quantitative analysis precision when applying these corrections to a flat surface sample and chip sample through a comparison with atomic absorption (AA) analysis.

Selection 10  Material Science

Measuring Polyethylene (PE)-Polypropylene (PP) Blend Samples

Polymeric materials are blends of two or more types of high molecular materials that are mixed to improve mechanical properties. Blends are often created to obtain properties that a single type cannot possess; however, this requires an understanding of component ratios. Unlike copolymers, mechanically blended polymeric materials exhibit the characteristics of each component, such as melting and crystallization, and multiple changes derived from each component can be observed through measurement with a DSC (differential scanning calorimeter). This research utilizes this process to introduce examples of determining the component ratios of blended high molecular materials by measuring the heat of fusion with a DSC.

Selection 11  Material Science

Analysis of Polycarbonate Using a Benchtop MALDI-TOF Mass Spectrometer

In recent years, recycling related laws have been enforced for the purpose of global environmental preservation, which in turn has increased the amount of recycled plastic products around us. This trend entails the needs of rapid and detailed analyses of recycled products. In such cases, sufficient information may be obtained by analyzing not the entire polymers but oligomers. Conventionally, oligomers are analyzed by combining rough separation using the dissolution/reprecipitation method, etc., and various chromatographic or spectroscopic techniques. On the other hand, recently MALDI-TOF mass spectrometers are extensively used for oligomer analysis. By using such instruments, the information of terminal groups and monomer units can be obtained rapidly. This article introduces an example analysis of polycarbonate, which was performed by combining rough separation of oligomers by the dissolution/reprecipitation method and measurement and analysis using the benchtop MALDI-TOF mass spectrometer “MALDI-8020”.

Selection 12  Material Science

Compression After Impact Testing of Composite Material

Carbon fiber reinforced plastic (CFRP) has a higher specific strength and rigidity than metals, and is used in aeronautics and astronautics to improve fuel consumption by reducing weight. However, CFRP only exhibits these superior properties in the direction of its fibers, and is not as strong perpendicular to its fibers or between its laminate layers. When force is applied to a CFRP laminate board, there is a possibility that delamination and matrix cracking will occur parallel to its fibers. Furthermore, CFRP is not particularly ductile, and is known to be susceptible to impacts. When a CFRP laminate board receives an impact load, it can result in internal matrix cracking and delamination that is not apparent on the material surface. There are many situations in which CFRP materials may sustain an impact load, such as if a tool being dropped onto a CFRP aircraft wing, or small stones hitting the a CFRP wing during landing. Consequently, tests are required for these scenarios. One of these tests is compression after impact (CAI) testing. CAI testing involves subjecting a specimen to a prescribed impact load, checking the state of damage to the specimen by a nondestructive method, and then performing compression testing of that specimen. This article describes CAI testing performed according to the ASTM D7137 (JIS K 7089) standard test method.

Selection 13  Material Science

Compression Test of Composite Material

Even among composite materials, carbon fiber reinforced plastic (CFRP) has a particularly high specific strength, and is used in aeroplanes and some transport aircraft to improve fuel consumption by reducing weight. Compressive strength is an extremely important parameter in the design of composite materials that is always tested. However, due to the difficulty of testing compressive strength there is a variety of test methods. A major compression test method is the combined loading compression (CLC) method found in ASTM D6641. The CLC method can be performed with a simple jig structure, untabbed strip specimens, and can be used to simultaneously evaluate strength and measure elastic modulus. We performed compression testing of CFRP according to ASTM D6641.