G5 : 바이오 세라믹스

G5-1 | 케나프 줄기 바이오매스로부터 셀룰로오스 나노섬유 생산

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Cellulose nanofiber (CNF) from biomass is getting attention in various field applications such as reinforcement material in ceramic. Given the significance of raw material quality control in industrial applications, this study investigated the characteristics of CNF and compared the effects of the different parts of bast fiber from kenaf biomass on its characteristics. CNF showed different characteristics depending on the origin of raw materials. CNF derived from the inner bast showed the most significant increase in carboxyl group content after carboxymethylation treatment, along with having the most extended length and thinnest width among the three samples. It showed the highest water retention value (WRV), resulting from the most extended fiber length related to water-holding capacity. In contrast, CNF derived from the outer bast showed the lowest WRV value. Based on our findings, removing the outer bast and reducing hemicellulose content from the kenaf stem could enhance the quality of CNF.

G5-2 | Liquid Electrodes for Cardiac Recording and Stimulation

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Wearable cardiac devices for recording the electrocardiograms (ECGs) are essential for the diagnosis of cardiovascular diseases. Conventional bio-interfaced devices using rigid metals with high moduli (〉1 GPa) have limitations in forming a tight interface with the heart tissue.

G5-3 | 단일 고용상 마그네슘-아연 합금 기반 마이크로 박막을 이용한 체내 환경내 고내식성 의료용 금속 전극

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고령화 사회가 도래함에 따라, 개인 건강의 검진과 치료에 대한 관심이 크게 늘고 있다. 이러한 수요에 맞춰 최근 체내 삽입형 의료전자소자의 발전은 실시간, 개인맞춤형 의료서비스의 개인화를 앞당기고 있다. 기존 생분해성 전자소자에 사용되는 마그네슘 기반 금속 전극은 높은 전기전도성, 생체적합성을 가지고 의료전자소자의 신호 감지, 기록, 자극을 주관하는 전도체로서 역할을 하고 있음에도 불구하고, 체내에서의 높은 반응활성도로 인한 빠른 용해 속도로 삽입형 전자소자의 짧은 동작수명을 초래한다. 본 연구에서는 마그네슘-아연의 이원계 합금을 단일 균질 고용상을 가진 마이크로 박막 스케일의 전극으로 제작하여 단일 마그네슘 전극 대비 우수한 내식성과 기계적 안정성을 가진 의료전자소자의 전극으로서 활용 가능성을 확인하였다. 또한, 다양한 체내 모사 용액 내에서의 마그네슘-아연 합금 박막의 생분해거동을 확인하였고, 세포생존율 실험을 통해 높은 체내 적합성을 검증하였다. 끝으로, 제작된 마이크로 박막 전극을 열치료용 저항체가 연결된 무선 전력 송수신코일 형태로 제작되어 체내 모사 열화 환경 내에서 단일 마그네슘 박막 전극 대비 더 오랜 시간 안정적인 발열성능을 보임으로써 체내 삽입형 생분해성 의료용 전자소자의 전도체로서의 성능을 검증하였다.

G5-4 | Retinal prosthesis with three-dimensional liquid microelectrodes for vision restoration

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Electronic retinal prosthesis, which stimulates the preserved retinal neurons electrically, has emerged as a promising method for vision restoration. However, the rigid electrodes of conventional retinal implant devices can inflict damage on the soft retina tissue, and have limited selectivity due to their poor proximity to target cells in the degenerative retina. Herein, we present a retinal prosthesis where flexible ultrathin photosensitive transistors are integrated with three-dimensional (3D) stimulation electrodes of liquid metals. These 3D microelectrodes can enhance the proximity to the target cells and provide effective charge injections to elicit neural responses in the retina, and their low Young's modulus can minimize the damage to the retina tissue. Furthermore, in-vivo experiments using a retinal degeneration mouse model demonstrate that the spatiotemporal distribution of neural responses on their retina can be mapped under selective localized illumination areas of light, suggesting the restoration of their vision.

G5-5 | A Platform for Surface-Polarity-Independent Assembly : Intragap Distance-Tunable Clustering of Nanoparticles Using Organosilicasomes

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The limited intragap distance tunability of clustering nanoparticles with different surface chemistries resulted in unwanted interference and restricted functionality. This leads to an urgent need for a new strategy that enables the assembly of nanoparticles with different polarities in defined compositions, distances, and

orientations. Herein, we used organosilicasome (OSS), an organic–inorganic hybrid compound covered with a surfactant, to cluster diverse nanoparticles with high configurational tunability regardless of their surface chemistry. OSS is capable of gluing nanoparticles and inducing co-encapsulation. The dissolvable characteristics of OSS facilitate controlled dissolution of nanoclusters, allowing the adjustment of the gap distance between nanoparticles. In consequence, OSS enables the synthesis of multifunctional nanoclusters, especially with enhanced fluorescence, by controlling the distance in long range between gold nanoparticles and quantum dots. These tunable and multifunctional nanoclusters should provide a new platform ranging from the exploration of interactions at the nanoscale to the advent of unconventional multifunctional nanomaterials.

G5-6 | 스마트 콘택트렌즈를 이용한 무선 비침습적 콜레스테롤 측정

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Elevated cholesterol levels can lead to arterial plaque accumulation, which can induce hyperlipidemia. As such, the timely and continuous monitoring of cholesterol is crucial for its early diagnosis and management. In response to this challenge, we present a soft smart contact lens designed to measure cholesterol levels in tear fluid, offering a novel way to non-invasively monitor hyperlipidemia patients through a smartphone interface. This smart contact lens incorporates an electrochemical biosensor to detect cholesterol concentrations, as well as a stretchable antenna and a near-field communication chip for wireless communication. Consequently, users only need a smartphone to operate this device seamlessly. Our validation with a hyperlipidemia rabbit model confirmed the correlation between tear and blood cholesterol levels, establishing the feasibility of this lens for cholesterol-related conditions. Further in-vivo studies with human participants demonstrated its high potential, emphasizing its wearability and reliability as a non-invasive healthcare monitoring device.

G5-7 | Affinity filter-incorporated hydrogel transistor for non-invasive potassium signal monitoring

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Living cells efflux intracellular K^+ ions for biological functions, such as neuronal excitation, signaling, and ion homeostasis, so intravital measurement of K^+ signals is important for studying cellular functions and pharmacokinetics. To real-time monitor K^+ effluxes, a patch-clamp technique has been the gold standard, despite its non-ion-selective voltage-to-current converting process that requires a reference electrode with periodic calibration. As an alternative, an FET covered with a valinomycin-containing polymer layer was suggested, but this field-mediated indirect method still suffers from signal misreading issues because multiple ions can also produce surface potentials by nonspecific adsorption. To address this problem, we aimed to achieve K^+-selective ion-to-ion amplification against complex biomixtures, and in this work, by emulating biological K^+ channeling and nerve signal transmission, we newly developed a K^+-selective membrane filter and integrated with a hydrogel ionic transistor. Briefly, by site-specific hydrophobic modification of G-quadruplex that contains K^+ binding sites, we created an artificial K^+ channel, which was embedded in a lipid bilayer with desirable alignment. As a result, while anion transport was perfectly blocked (~100%), K^+-preferred ion transport among alkali metal ions of similar size was successfully achieved. Using our K^+-selective membrane filter-gated hydrogel ionic transistor, we succeeded in non-invasive monitoring of K^+ signals during cellular growth in real time.

G5-8 | 왕겨 유래 실리카를 이용한 고부가가치 소재 개발 기술

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왕겨는 전체 중량의 12~20 wt%의 실리카를 포함하고 있는 식물체로써 실리카를 얻을 수 있는 재생원료이다. 최근 탄소중립이 중요한 사회적 이슈로 대두되면서 기존 석유화학산업 유래 원료를 대체하거나 고에너지 소비와 환경오염을 유발하는 공정을 통해 생산되는 원료에 대한 대체 원료 발굴 및 활용이 적극적으로 요구되고 있다. 본 연구에서는 왕겨 유래 실리카를 활용하는 기술의 동향과 이에 대한 문제점을 고찰할 것이다. 왕겨 유래 실리카 활용은 왕겨로부터 실리카를 추출하는 기술과 왕겨 유래 실리카를 원료로 활용하여 고부가 소재를 합성하는 기술로 구성되어 있다. 왕겨로부터 실리카를 추출하는 다양한 기술들이 있으며 각 기술에 대한 후속공정의 장단점을 고찰할 것이며 특히 상용화공정을 위한 이슈를 살펴볼 계획이다. 또한 왕겨 유래 실리카를 사용한 고부가 소재의 사례를 돌아보면서 왕겨 유래 실리카의 장점을 살린 적용 분야에 대해서 살펴보고자 한다.

G5-9 | Fabrication of compositionally graded zirconia products with high translucency using digital light processing (DLP) technique

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Zirconia ceramics, due to its excellent mechanical properties along with reasonably high translucency and biocompatibility, have gained popularity in the field of dental prosthetics. One of the widely used method for fabricating zirconia prosthesis was utilizing dental CAD/CAM technique, nonetheless, was claimed to have several issues while machining zirconia blanks. Meanwhile, additive manufacturing zirconia products arose as promising substitute to manufacture dental prostheses, however, most of previous studies utilized single source of material for fabrication. Usage of single material within fabrication was a challenge to meet the needs of people who preferred more aesthetically satisfying prostheses, which mimics the gradient hue transition of natural teeth. Thus, this research aims to present novel additive manufacturing method with functionally graded material (FGM) concept for fabricating compositionally graded zirconia products via digital light processing (DLP) technique, with comprehensive evaluation of 3D printed zirconia products to be utilized in clinical applications.

Two differently shaded (A0 and A3 shade) photo-sensitive zirconia suspensions with high solid loading of 50 vol% were prepared, while maintaining printable rheological and photo-curing properties. By controlling the extrusion ratio of both suspensions through static mixer which is attached to custom-built DLP 3D printer, solidified layers of slurries in functionally graded manner at stacking direction was additively manufactured, hence, compositionally graded zirconia products including dental prosthesis were fabricated. Compositionally graded zirconia products showed linear shade and translucency transition, along with 3-point flexural strength of 702 MPa, followed by in-vitro assessment of marginal fit which was evaluated as 41.3μm. The results of this research regarding the compositionally graded zirconia product demonstrates novel additive manufacturing method for fabricating functionally graded objects, as well as showing high possibility of 3D printed products to be adopted in clinical usage.

G5-10 | 바이오 구조전자소자 3D 프린팅 기술 및 의료소자 응용

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조직 및 장기와 원활하게 결합하여 정밀한 진단과 치료를 제공하도록 설계된 삽입형 디바이스는 빠르게 발전하고 있습니다. 기존의 대량 생산 방식의 2D 리소그래피를 통해 삽입형 디바이스를 설계할 땐 복잡한 인체의 특성에 맞추는 어려움이 있습니다. 가령 개인마다 조직과 장기의 크기와 모양이 다르고, 복잡한 입체 요소들을 가지고 있고, 밀도가 높은 조직 층으로 둘러싸인 제한된 자유 공간을 가지고 있습니다. 또한 인터페이스 전극을 따로 두거나 커프 전극처럼 연결하는 과정에서 전극의 면역학적, 기계적 문제들이 발생하기도 합니다. 3D 프린팅은 이러한 문제를 새롭게 해결하며 개인 맞춤형 3차원 형태로 디자인이 가능한 장치를 제작할 수 있는 방식을 제공해줍니다. 이러한 방식은 필수 전자 재료를 3차원으로 인쇄하고 회로를 구성하는 동시에 제한된 공간 활용을 극대화할 수 있습니다. 또한 기능 회로와 인터페이스 전극을 일체형으로 프린팅하여 본체와 전극의 분리가 필요하지 않습니다. 더불어 삽입 후 리스크가 많은 제거술을 필요로 하지 않도록 생분해가 가능한 물질들로 구성되어야 합니다. 따라서 본 연구에서는 모든 전자 소자가 생분해가 가능하며 3D 프린팅이 가능한 디바이스 제작 기술을 개발하였습니다. 반도체, 도체 및 유전체 부품을 위해 특수하게 제작된 생분해성 잉크를 사용하여 3D 맞춤형 회로 기반의 삽입형 디바이스를 타겟 구조에 맞춰 원활하게 디자인할 수 있습니다. 이 기술을 기반으로 전극부의 분리가 없는 일체화된 생분해성 무선 튜브형 자극기는 절단된 말초 신경의 기능 회복을 가속화할 수 있는 치료 능력을 입증했습니다. 또한 다양한 센서 예시를 통해 3D 임베딩 및 자유 표면 프린팅의 확장된 기능도 제안되었습니다.

G5-11 | Ligand-Free Side-Patched Gold Nanorods from Salt-Assisted Anisotropic Structural Tuning of Silica Shells

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The precise and selective modification of the silica shell in anisotropic structure on gold nanorods (AuNRs) remains a significant challenge for enabling controllable material self-assembly and advancing their applications in diverse fields. Herein, we present a novel method for synthesizing ligand-free, side-silica patched AuNRs. By employing a simple treatment with sodium iodide salt, we achieved a high yield of 86% yield in selectively coating silica on the side of the AuNRs. A series of controlled experiments using different salt types revealed that the strong adsorption energy and high negative anionic strength of iodide anions facilitated the selective deposition of silica on AuNR tips while

inhibiting growth in another region. Physical and optical property comparisons with previously reported silica-coated AuNRs confirmed the absence of substances attached to the tips. Furthermore, removal of the surfactant through solvent exchange with ethanol revealed tip-to-tip assembly of the particles. Simulation results demonstrated the formation of strong electromagnetic fields in the exposed tip regions and nanogaps between the tips, leading to higher enhanced surface-enhanced Raman scattering (SERS) intensities compared to other silica-coated AuNR structures. This work provides an efficient technique to produce anisotropic silica-coated AuNRs for various applications as well as to the design of the directional building blocks for self-assembly.

G5-12 | In-vivo integration of soft neural probes through high-resolution printing of liquid electronics on the cranium

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The printed neural interface system comprises soft neural probes, cranial circuits, and form factor-free batteries. First, liquid metal-based neural probes are fabricated structurally and mechanically similar to neurons (~ 5 um), minimizing the formation of inflammation and immune responses. Second, liquid metal-based cranial circuits are directly printed on the surface of the cranium for electrical connection to neural probes, which are implanted in multiple brain regions of a single subject, with adaptable geometries. Third, liquid metal-based electrical interconnections with subsidiary electronics form miniaturized and conformal circuits on the cranium within the body, which maximizes the integrity of electronics to biological systems for the battery-free system. Also, printed rechargeable built-in power sources along the curvature of the cranium are placed on the liquid metal-based cranial circuits connected with soft neural probes, minimizing bulky head-mounted configurations for a battery-powered system. Furthermore, in-vivo recording using our device in freely moving mice demonstrated the simultaneous recording of local field potentials (LFPs) and single-unit spiking in multiple regions of the brain, as well as its biocompatibility and stability for the long term (~ 33 weeks), and these results suggest its broad and practical applications for various bioelectronics and neuroscience research.

G5-13 | A continuous biogenic silica extraction from rice husk using attrition ball milling and alkali hydrothermal treatment processes

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Rice husk is the most Si-rich renewable biomass and can be used as a raw material for producing Si-based materials. With the increasing interest in utilizing rice husk as a renewable resource, the development of a robust silica extraction method is required. In generally to order extract silica from rice husks. In the case of rice husk, it is one of the industrially valuable by-products because a contain amount is annually steadily generated. Alkali extraction was performed under high temperature and high pressure conditions. In this study, continuous extraction of silica from rice husks was carried out at 80℃ and atmospheric pressure. And a one-pot alkali hydrothermal and ball-milling continuous silica extraction method was developed at the pilot scale. Three residence times (50, 100, and 150 min) were selected to compare the performance of the continuous extraction process depending on the residence time. The highest silica extraction yield (86.0%) was achieved at the longer residence time of 150 min, whereas the highest silica production quantity was obtained at a residence time of 50 min. The energy consumption for processing 1 kg of rice husk was 3.49, 4.22, and 5.22 MJ/kg at residence times of 50, 100, and 150 min, respectively. The one-pot continuous silica extraction process was performed for 150 h to verify the stability of the process. During long-term operation, the process exhibited a constant solid content and stable silica extraction yield. The silicate solution obtained by the one-pot continuous process was successfully used to synthesize size-controlled spherical silica particles, which had a purity of 99.1 wt% and amorphous structure. Overall, this study presents a novel continuous silica extraction method for the efficient recovery of silica from rice husk-based biorefineries.