PG5A : 바이오 세라믹스

PG5A-1 | Manufacturing and Characterization of Dental Crowns Made of 5-mol% Yttria Stabilized Zirconia by Digital Light Processing

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We herein report manufacturing of dental crowns made of 5-mol% yttria partially stabilized zirconia (5Y-PSZ) with desired mechanical properties, optical translucency and dimensional accuracy using digital light processing (DLP) for clinical uses. The use of a high solid loading of 50 vol% in 5Y-PSZ suspensions allowed sintered 5Y-PSZ to have high relative densities (99.03 ± 0.39%), thus offering high flexural strength (625.4 ± 75.5 MPa) and % transmittance (31.4 ± 0.7). In addition, high dimensional accuracy (RMS for marginal discrepancy = 44.4 ± 10.8 μm and RMS for internal gap = 22.8 ± 1.6 μm) was achieved by carefully designing initial dimensions of dental crowns and photocuring time for 3D printing.

PG5A-2 | 균일한 나노 기공을 갖는 3차원 자성 PDMS 나노 구조체 제작

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자기장에 민감한 다공성 고분자 스펀지는 외부 자기장에 의해 원하는 위치에 원하는 양만큼 약물을 전달할 수 있어 전 세계적으로 많이 연구되고 있다. 폴리디메틸실록산(PDMS)은 뛰어난 생체 안정성과 생물학적 호환성으로 인해 기존 자기장에 민감한 다공성 고분자 스펀지의 재료로 많이 사용되고 있다. 기존 선행연구들에 따르면 설탕의 증발을 이용해 마이크로 및 미크로 기공을 가진 다공성 고분자 스펀지를 제작하였지만, 기공의 크기가 균일하지 않아 미세한 약물배출량을 효과적으로 제어하기에 한계가 있고, 샘플마다 자기장세기에 대한 약물배출량이 달라 실제 상용화에 어려움을 겪고 있다. 기존 자기장에 민감한 다공성 고분자 스펀지의 문제점을 해결하기 위해 정렬 나노 기공의 도입은 자기장 세기에 선형적인 약물 배출 효과로 인해 매우 미세한 양을 정확히 조절할 수 있고, 스펀지의 부피만 같으면 자기장 세기에 따른 약물 배출량이 거의 일치하여 상용화에도 이다. 본 연구에서는 균일한 나노 크기(~200nm)의 기공을 갖는 카보닐 철과 혼합된 PDMS 스펀지를 제작하였다. 나노 구조 템플릿 제작을 위해 근접장 나노패터닝(Proximity-field nanopatterning, PnP) 기술을 사용하였으며, 선택적 용해를 통해 3차원 자성 PDMS 나노 구조체를 제작하였다.

PG5A-3 | Development of Bone Regeneration: Bioessential Inorganic Molecular Wire-Reinforced 3D-Printed Hydrogel Scaffold

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Materials with physicochemical properties and biological activities similar tothose of the natural extracellular matrix are in high demand in tissueengineering. In particular, Mo3Se3−inorganic molecular wire (IMW) is apromising material composed of bioessential minerals and possessnanometer-scale diameters, negatively charged surfaces, physical flexibility,and nanotopography characteristics, which are essential for interactions withcell membrane proteins. Here, an implantable 3D Mo3Se3−IMW enhancedgelatin-GMA/silk-GMA hydrogel (IMW-GS hydrogel) is developed forosteogenesis and bone formation, followed by biological evaluations. Themechanical properties of the 3D printed IMW-GS hydrogel are improved bynoncovalent interactions between the Mo3Se3−IMWs and the positivelycharged residues of the gelatin molecules. Long-term biocompatibility withprimary human osteoblast cells (HOBs) is confirmed using the IMW-GShydrogel. The proliferation, osteogenic gene expression, collagenaccumulation, and mineralization of HOBs improve remarkably with theIMW-GS hydrogel. In in vivo evaluations, the IMW-GS hydrogel implantationexhibits a significantly improved new bone regeneration of 87.8±5.9% (p

PG5A-4 | Enhancing Bone Tissue Regeneration with Natural Bone-Mimicking Nanopore-Incorporated Hydroxyapatite Scaffolds

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A considerable number of studies has been carried out to develop alloplastic bone graft materials such as hydroxyapatite (HAP) that mimic the hierarchical structure of natural bones with multiple levels of pores: macro-, micro-, and nanopores. Although nanopores are known to play many essential roles in natural bones, only a few studies have focused on HAPs containing them; none of those studies investigated the functions of nanopores in biological systems. We developed a simple yet powerful method to introduce nanopores into alloplastic HAP bone graft materials in large quantities by simply pressing HAP nanoparticles and sintering them at a low temperature. The size of nanopores in HAP scaffolds can be controlled between 16.5 and 30.2 nm by changing the sintering temperature. When nanopores with a size of ~ 30.2 nm, similar to that of nanopores

in natural bones, are introduced into HAP scaffolds, the mechanical strength and cell proliferation and differentiation rates are significantly increased. The developed HAP scaffolds containing nanopores (SNPs) are biocompatible, with negligible erythema and inflammatory reactions. In addition, they enhance the bone regeneration when are implanted into a rabbit model. Furthermore, the bone regeneration efficiency of the HAP-based SNP is better than that of a commercially available bone graft material. Nanopores of HAP scaffolds are very important for improving the bone regeneration efficiency and may be one of the key factors to consider in designing highly efficient next-generation alloplastic bone graft materials.

PG5A-5 | Synthesis of Porous Hydroxyapatite Microspheres by Photocuring of Hydroxyapatite Emulsions containing Terpene Crystals

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Camphene is one of the most widely used as pore-forming agents for freeze-casting of porous ceramics, which solidified camphene crystals can be sublimated, leaving pores in ceramic objects. However, there was a limitation to the previous methods that microspheres synthesized using only camphene were fragile to maintain their shapes and did not show dendritic growth enough when observed by scanning electron microscopy. Therefore, we employed camphene-camphor alloys together as porogens, since the solidification temperature of slurry is increased by adding camphor compared to the slurry with camphene alone, thus an increase in solidification rate is followed when frozen at the same temperature. In addition, adding camphor showed higher rigidity after freezing, making it easier to retain spherical shape. As a ceramic material, hydroxyapatite with good biocompatibility and biodegradability is used to fabricate porous microspheres. Experimental procudure is conducted by following steps: slurry preparation, emulsion method, freezing, photocuring, freeze-drying. A number of elongated pores were observed inside green bodies, which is the typical feature of dendritic growth of the camphene-camphor alloys during freezing. The fraction and size of pores could be tailored by adjusting terpene contents in hydroxyapatite slurries. Microspheres after heat-treatment can be used in bone grafting or bone fillers due to their bone regeneration ability to induce bone ingrowth through pores in microspheres.

PG5A-6 | PtNP-embedded TiO_2 Aerogel with Enhanced Ionization for Solid-state System in Laser Ionization and Desorption

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Nanoporous TiO_2 aerogel with noble metal Pt nanoparticle (PtNP) is presented to enhance both ionization and desorption process in laser irradiation environment for mass spectrometry applications. The PtNP-embedded TiO_2 aerogel was synthesized via (1) PtNP synthesis by citrate reduction and (2) sol-gel process after forming PtNP dispersion in TiO_2 precursor solation. The synergic effect of synthesized aerogel for enhanced ionization was demonstrated in terms of the photocatalytic activity by dye degradation in suspension environment. The origin of the catalytic performance was analyzed by the contact at the PtNP-TiO_2 interface. Conditions for mass spectrometric applications were optimized by using model small molecule analytes. Finally, small lipid biomarker for sepsis was analyzed to validate the enhanced ionization and desorption performance for LDI-ToF mass spectrometry instrument.

PG5A-7 | TiO_2 aerogel-based combi-matrix system for LDi-MS in Sepsis Diagnosis

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Aerogel, a nanoparticle-based 3D porous network structure, is prospective for laser irradiation environment in LDI-MS application. In this study, TiO_2 aerogels were applied to the LDI-MS as a matrix for quantitative analysis of small molecules in clinical diagnosis. Aerogels for this study were synthesized by super critical drying (SCD). Synthesized aerogels were optimized via photocatalytic efficiency from methylene blue (MB) degradation. Effect of pore size, aerogel particle size, and phase composition were investigated as optimization factors. MS analysis on small molecule with aerogel matrices showed reduced noises and enhanced analyte signals compared to conventional organic matrix-based MS analysis. Furthermore, a combi-matrix, mixture of inorganic aerogel and organic matrix, was applied to enhance MS analysis by higher signal-to-noise (S/N) ratio. Finally, we conducted LDI-MS analysis with optimized aerogel-based combi-matrix system on lysophosphatidylcholines (LPCs), which is known for biomarker of sepsis. The cut-off level of LPC 16 and in serum was obtained by patient sample and healthy volunteers for medical diagnosis of sepsis.

PG5A-8 | Optimization of dilute sulfuric acid neutralization reaction conditions based on the proportion of natural and synthetic carbonate ceramic materials

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The study aimed to develop an effective method for neutralizing dilute sulfuric acid, which is a significant contributor to environmental pollution in industrial processes. Using alkaline chemicals to neutralize dilute sulfuric acid causes a lot of waste and high costs. To solve this problem, the study used waste ceramic materials and synthetic materials that contain carbonates to neutralize dilute sulfuric acid and recover byproducts. The study analyzed the crystallinity, specific surface characteristics, and particle sizes of ceramic materials and synthetic materials that contain carbonates, and optimized the neutralization process conditions using these materials. The study adjusted the weight ratio of ceramic materials depending on the concentration of sulfuric acid to determine the optimal neutralization conditions, and checked the neutralization reaction time of dilute sulfuric acid depending on the input ratio of ceramic materials and synthetic materials that contain carbonates. The study analyzed the crystallinity after neutralization to check the conversion degree to calcium sulfate. Through this optimization process using ceramic materials that contain carbonates, the study neutralized dilute sulfuric acid that is produced in industrial processes, and confirmed the possibility of environmental protection and recycling of waste resources.

PG5A-9 | Optimizing the fabrication Process for Zirconia Biomaterials as a Multifunctional Scaffold

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In this study, the fabrication process for using zirconia, a biologically inert material, as a multi-functional scaffold material was optimized. A synthesis method yielding a high specific surface area for zirconia, allowing for drug delivery function, was developed and characterized using BET analysis. Zirconia with various strengths was manufactured and flexural strength was measured to be used for each human part by adjusting compression time and pressure using a universal material tester (UTM) to be used as a scaffold. Furthermore, drug delivery function of zirconia were confirmed through UV-vis analysis, demonstrating sustained drug release behavior over 30 hours. These findings show the drug delivery potential of zirconia, a biologically inert material, and establish a manufacturing process for its application as a scaffold. Further research is expected to enable biocompatible materials to be utilized in more diverse forms in the medical field.

PG5A-10 | Colorimetric biosensor with high sensitivity using bioceramic nanosheet

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Hormones involved in many bio reaction and function, is one of important biomarkers that tell us about our health. To determination of the hormone, antibody- and enzyme-based methods including ELISA are commonly used, which have the advantage of having high specificity and sensitivity. However, the enzymatic reaction is expensive and unstable at room temperature, thus it requires harsh storage conditions. In this study, we develop a hormone diagnostic platform using bioceramic nanosheet, as an alternative to HRP, to overcome the limitation of enzyme. The nanosheet is stable compared to natural enzymes and has a large surface area that may allow for signal amplification. For this purpose, we optimized how to bind the desired target hormone to the sheet. Compared with commercial ELISA kit for estradiol, our system could detect 100-times lower concentration of target. We expect that this research can be applied to other hormones, as well as contribute to early and accurate diagnosis of hormone-related diseases in a painless way.

PG5A-11 | Development of biocompatible SiO_2 nanoparticles for gene therapy

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Necroptosis contains two mechanisms' properties, programmed cell death and immune response based on secreting DAMPs to surrounding tissues. This multimodal process can take advantages in the cancer therapy. We attempted to induce necroptosis by delivering RIPK3-related to necroptosis, in the form of mRNA. However, mRNA is easily degraded, thus it is difficult to reach target cells. As a result, a carrier that roles as a protector and carrier for mRNA is required. In this study, we developed

a SiO_2-based porous nanoparticle that can effectively deliver mRNA into target cancer cells. We successfully delivered and induced the expression of the mRNA to cells via the delivery vehicle and found that it effectively inhibited tumor growth in a cancer xenograft mouse model. The results suggest that the activation of necroptosis provides a new approach for therapy, and we believe that this work could serve as a foundation for the development of SiO_2-based nanotechnology therapeutics in various diseases and anticancer treatments.

PG5A-12 | 심층공융용매와 옥살산을 유기용매로 이용한 셀룰로오스 순도 생산

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Cellulose derived from lignocellulosic biomass offers a wide range of applications such as ceramic material The use of cellulose is getting attention because it is a sustainable and renewable resource. The purification of cellulose is one of basic step to use cellulose. Previous studies used pulping and environmental hazardous solvents such as sulfuric acid and hydrochloride. Those are energy-consuming and environmentally harmful. The green approach has been developed to extract high-purity cellulose from kenaf using deep eutectic solvents (DESs) and oxalic acid. The acid hydrolysis was performed to remove hemicellulose using oxalic acid. The delignification of kenaf was performed by using deep eutectic solvents (DES) instead of pulping process. In this study, chloride salts and ethylene glycol were used as a hydrogen bond acceptor. When citric acid was used as a hydrogen bond donor, the delignification efficiency significantly improved, finally 96% of cellulose purity was obtained after bleaching.

PG5A-13 | 세슘 리드 브로마이드 페로브스카이트 광센서의 defect 패시베이션

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Perovskite QD of $CsPbBr_3$ was synthesized using thermodynamic with a featured absorption peak at 475 nm. For the passivation of photosensor surface, parylene film was used as the passivation layer of photosensors based on the synthesized perovskite QD of $CsPbBr_3$. The increase in sensitivity through the passivation with the parylene-C film was analyzed to be resulted from the protection against to the water and defect repair of the Br- vaccancy. Parylene N, F, and C were used to prove the vaccancy repair properties of parylene passivation. The PL peak shows blue-shift after the parylene passivation and the time-resolved PL shows the enhanced life time from 2.67 ns to 5.97 ns. The energy band parylene-C passivated QD was estimated to be 2.73 eV. The sensitivity of the photosensors was estimated to be 0.39 ($nA/\mu W/cm^2$) for the synthesized QD and 0.87 ($nA/\mu W/cm^2$) for the parylene-C passivated QD. Finally, the photosensor based on the parylene-C passivated QD was demonstrated for the detection of the chemiluminescence signal from ELISA detection of bacteria.

PG5A-14 | 페로브스카이트 퀀텀닷 기반의 광센서를 이용한 바이오센싱

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Perovskite QD of $CsPbBr_3$ was synthesized using thermodynamic control to have uniform size of less than 5 nm with a featured absorption peak at 458 nm and the bandgap energy of 2.61 eV. A sensitive photosensor was prepared by mixing QD and the MoS_2 nanoflake and sintering at 300ºC. When two kinds of photosensors based on the synthesized QD and the QD- MoS_2 nanoflake were compared, the sensitivity of the photosensors was estimated to be 0.076 ($nA/\mu W/cm^2$) for the synthesized QD and 0.23 ($nA/\mu W/cm^2$) for the synthesized QD- MoS_2 nanoflake. From the analysis of the electronic structure, the transfer of excited electron at the conduction band of the synthesized QD through the conduction band of MoS_2 at lower energy level was determined to be more effective than the direct transfer to the gold electrode. For the passivation of photosensor surface, parylene-C film was used as the passivation layer of photosensors based on the synthesized perovskite QD of $CsPbBr_3$. The increase in sensitivity through the passivation with the parylene-C film was analyzed to be resulted from the blocking of trap states from PL-analysis and I-V curve analysis. Finally, the photosensor based on the synthesized QD- MoS_2 nanoflake was demonstrated for the detection of the chemiluminescence signal from ELISA kits for the detection of human hepatitis B surface antigen (hHBsAg), human immunodeficiency virus (HIV) antibody, cancer biomarker called alpha-fetoprotein (AFP).

PG5A-15 | 전기화학 측정 기반의 혈중 포스포리피드 농도를 이용한 패혈증 진단

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Electrochemical analysis of total phospholipids was performed for the diagnosis of sepsis. The influence of electrode materials on the analysis of the chromogenic substrate was analyzed using Au, graphite, and pyrolyzed carbon electrodes. The total phospholipid analysis based on electrochemical analysis with pyrolyzed carbon was used for diagnosis of sepsis using sera from healthy volunteers, systemic inflammatory response syndrome (SIRS), and severe sepsis patients. The analysis results using the optical measurement and the electrochemical analysis were compared for the serum samples from sepsis patients and healthy controls. Additionally, the interference of human serum on the optical measurement and electrochemical analysis was estimated by signal-to-noise (S/N) calculation. The assay results of the levels of other biomarkers for sepsis (C-reactive protein and procalcitonin) and the total phospholipid levels obtained using the optical measurement and electrochemical analysis methods were statistically similar. Finally, the mortality of patients, indicated by the results of the total phospholipid assay performed using the electrochemical analysis of the patient samples collected daily (1, 3, and 7 day(s) after admission to hospital), was compared with the patient mortality assessed via conventional severity indexes, such as the SOFA and APACHE Ⅱ scores. The 28-day survival rate was estimated by Kaplan–Meier survival analysis based on the total phospholipid level of patient samples that were obtained after 1, 3, and 7 day(s) from hospital admission.

PG5A-16 | 굴 패각을 이용한 탄산칼슘 추출 방법 및 이를 이용한 생분해성 필름 제작

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2017년 기준으로 한국에서 매년 약 28만톤의 굴 패각이 발생한다. 그 중 18만 톤만이 비로로써 사용되나, 패각 내 잔존된 염때문에 이마저도 활용에 어려움이 있는 실정이다. 이에 본 연구는 버려지는 굴 패각을 사용하여 탄산칼슘을 추출하고, 굴 패각 기반 탄산칼슘을 원료로 사용하여 산업체에 적용할 방안을 탐구하기 위한 목적으로 수행되었다. 본 연구에서는 탄산칼슘 추출을 위해 4M HCl을 사용하여 패각을 용해해 CaCl 용액을 제작하였다. 용액으로부터 고체 잔여물을 분리한 후, CaCl 용액에 Na_2CO_3를 첨갛하여 1시간 동안 600rpm으로 교반하며 반응시켰다. 진공 여과를 통해 생성된 침전물과 용액을 분리하고, 생성된 침전물을 증류수에 30분 동안 세척 후 100°C에서 12시간 동안 건조하였다. 최종적으로 획득한 탄산칼슘은 XRF, ICP-OES, XRD, SEM ,PSA를 통해 제작한 탄산칼슘의 특성 및 성분을 파악하였다. 한편 바이오 플라스틱 산업이 점진적으로 증가하는 반면에, 바이오 플라스틱은 석유계 플라스틱과 비교해서 강도가 약한 경향이 있다. 탄산칼슘은 일반적으로 포장 업계에서 플라스틱 필름에 적정량 첨가하였을 때 휨 탄성계수, 충격강도, 강성, 인열강도 등을 개선하는 것으로 알려져 있다. 이에 본 연구에서는 상기 굴 패각에서 합성한 탄산칼슘을 바이오플라스틱인 생분해성 필름에 적용하여서 굴 패각 유래 탄산칼슘의 적용성을 확인하였고 궁극적으로 폐기되는 굴 패각의 부가가치와 효용 가치를 향상시켰다.

PG5A-17 | 코로나바이러스 변이내성 중화제를 위한 수용체 모방 하이브리드 생체고분자 개발

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Viruses mutate over time, discouraging the development of antiviral prophylaxis and therapy; along with stronger binding to host cell receptors, the variants escape the vaccines and neutralizing agents more easily. In this work, we focus on enhanced receptor binding of viral variants and demonstrate generation of receptor-mimicking synthetic biopolymers, capable of strongly interacting with viruses and even their variants. In developing the receptor mimic, a receptor-derived hotspot peptide is synergistically integrated with exceptionally soluble nucleic acids that serve not only as a structural stabilizer, but also as a binding cooperator. From a myriad of peptide-coupled random nucleic acids (~10^{14}), the receptor-mimicking synthetic biopolymers are readily isolated to maximize hotspot interaction of the embedded peptide. The de novo selected receptor mimic exhibited a great binding tolerance to all the coronavirus VOCs: Alpha, Beta, Gamma, Delta, and Omicron, along with efficient neutralization. Surprisingly, compared to the wild-type, it boosted the binding affinity by ~500% to the Omicron, the most mutated, transmissible, and dominant VOC.

PG5A-18 | Thermally Stable and Reusable Ceramic and Polymer Encapsulated CalB Enzyme Particles for the Enzymatic Hydrolysis and Acylation

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This study reports the preparation of silica coated and nano-fructosome encapsulated Candida antarctica lipase B particles (CalB@NF@SiO_2) and demonstration of their enzymatic hydrolysis and acylation. CalB@NF@SiO_2 particles were prepared as a function of TEOS concentration (3-100 mM). The particle size analysis, thermal stability, catalytic activity in different pHs, and reusability of CalB@NF@SiO_2 were demonstrated.

Optimal stability of CalB@NF@SiO_2 was found at temperature of 35 ℃ and pH 8. The CalB@NF@SiO_2 particles were reused for seven cycles to evaluate their reusability. Furthermore, he determination of CalB enzyme in CalB@NF@SiO_2 was achieved by Bradford assay and TGA analysis. Catalytic constants (K_m, V_{max}, and K_{cat}) of CalB@NF@SiO_2 were calculated with Michaelis-Menten equation and Line-weaver Burk plot. In addition, enzymatic synthesis of benzyl benzoate was demonstrated by an acylation reaction with benzoic anhydride. The efficiency of CalB@NF@SiO_2 for converting benzoic anhydride to benzyl benzoate by the acylation reaction was 97%, indicating that benzoic anhydride was almost completely converted to benzyl benzoate. Consequently, CalB@NF@SiO_2 particles are reusable with high stability at optimal pH and temperature.

PG5A-19 | Highly Bioresorbable and Biomineralized uncalcined Hydroxyapatite and In vitro Dissolution Assessments

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This study reports on the preparation of highly bioresorbable and biomineralized hydroxyapatite using a non-calcination process and the assessment of in vitro dissolution in citric acid. During the dissolution, rod-shaped particles of calcium citrate was newly formed from uncalcined hydroxyapatite (un-HAp), and these particles showed better biocompatibility than those formed from calcined hydroxyapatite (HAp). The particle size, Ca/P ratio, and crystallinity of prepared un-HAp were 13.02 μm, 1.52, and 85.8%, respectively. Moreover, in vitro dissolution assessments of un-HAp were performed to demonstrate the bioresorbability and biomineralization to calcium citrate for 20 days at 37 °C in a citric acid buffer, as compared to HAp. During the dissolution, the calcium and phosphorus ions in un-HAp are released more rapidly than those in HAp. The calcium and phosphorus ions released from the HAp and un-HAp are transformed into the new rod-shaped particles of calcium citrate with different lengths and diameters. In particular, the concentrations of released calcium and phosphorus ions from un-HAp are initially increased and then decreased by this transformation. This study confirmed the new formation of calcium citrate rod-shaped particles through SEM, FIB, EDS, and XRD. In addition, un-HAp powders with dissolution for 20 days demonstrated non-toxic properties in a cytotoxicity evaluation.

PG5A-20 | Comparison of fluorine-free superhydrophobic silica particles and mesoporous silica particles and gravure coating on PLA films

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This work reports a comparison of fluorine-free superhydrophobic silica particles and mesoporous silica particles (SPs and MSPs) grafted by hexamethyldisilazane (HMDS) and application for gravure coating on the biodegradable PLA films. The surface area of SPs and MSPs are 10.02 m^2/g and 758.81 m^2/g, and the amounts of grafted HMDS onto SPs and MSPs are 0.5%, and 9.5%, respectively. Superhydrophobicity characterization of SPs and MSPs was demonstrated using WCA, TGA, BET, TEM, UV-Vis. and FE-SEM. HMDS grafting on SPs and MSPs was confirm as a function of the concentrations from 0 to 1.6M. The WCAs of HMDS@SPs and HMDS@MSPs are 152.07° and 151° at a HMDS concentration of 1.6M (WCA of unmodified SPs and MSPs: 13.85°, 27.65°). To apply the superhydrophobic PLA film coating, HMDS@Silica and HMDS@MSPs were mixed with gravure solution. As a result, the WCA of PLA film with HMDS@SPs and HDMS@MSPs are 99.61° and 152.28°, respectively, and the WCA decreased significantly as HMDS@SPs were mixed with the gravure solution.

PG5A-21 | Preparation and In vitro Dissolution Evaluation of 45S5, S53P4 and 13-93 Bioactive glasses

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This study reports the preparation and in vitro dissolution evaluation of the bioactive glasses (BGs) such as 45S5 ($45SiO_2$-$24.5Na_2O$-$24.5CaO$-$6P_2O_5$), S53P4 ($53SiO_2$-$23Na_2O$-$20CaO$-$4P_2O_5$) and 13-93 ($53SiO_2$-$6Na_2O$-$20CaO$-$4P_2O_5$-$5MgO$-$12K_2O$). The BGs were synthesized by melt-and-milling process. The obtained powder was milled with a mortar. The characterization was demonstrated using ICP-OES, XRD, and FE-SEM. In addition, the in vitro dissolution evaluation of the BGs was demonstrated according to ISO-10093-14 in Tris buffer and Citric acid buffer at 37 ℃ for 21 days. As a result, Ion release was highest in the order of 45S BGs 〉53S BGs 〉13-93 BGs, and ion

release was about three times as high in citric acid buffer than in Tris buffer. Also, after 21 days of dissolution evaluation, both Tris buffer and citric acid buffer formed a calcium phosphate layer on the surface, In Tris buffer, the calcium phosphate layer formed on the surface aggregated into a rod shape, while in citric acid buffer, the calcium phosphate layer formed on the surface into a thin rod shape and a cocoon-like structure. The cause of the cocoon-like structure in the citric acid buffer was that the more reactive parts of the calcium phosphate formed a layer on the surface of the BGs, while the less reactive parts of the calcium phosphate reacted with the Si ions released in the citric acid buffer, resulting in a cocoon-like structure. The dissolution evaluation showed that a calcium phosphate layer formed better on the surface of BGs in Tris buffer than in citric acid buffer.

PG5A-22 | Semi-permeable protocells enable direct target detection in non-purified blood

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In controlling the transport of molecules, many different types of size-selective membranes have been used in a wide range of applications, including water purification, electrolyte separation of batteries, and biological compartmentalization. In particular, regulation of molecular transport can be highly useful for biosensors; effective exclusion of fouling molecules can be directly linked to sensitive and selective detection of targets even in complex body fluids. In this work, we explored the potential of semi-permeable protocells for the point-of-care testing with no sample purification. Due to the small size, the membrane of the protocells can exclusively allow the entry of analytes with no access of nucleases and charged proteins, which would be an optimal environment of encapsulated DNA sensing probes. To this end, we first introduced the water-in-oil emulsion to construct the semi-permeable microcapsules composed of self-assembled protein-polymer amphiphiles. In the microstructure of the cross-linked membrane, newly designed aptasensors were subsequently enclosed to report the presence of various biomarkers via strong fluorescent signaling. We demonstrate that the aptasensor-encapsulated protocells achieve multiplexing real-time detection of estradiol, dopamine, and cocaine even in undiluted blood and serum.

PG5A-23 | 3차원 인쇄형 구조전자소자 및 전자약 응용

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신체 조직 및 장기와 정교하게 인터페이스하여 정밀한 진단과 치료를 제공할 수 있는 삽입형 전자기기의 개발은 현재 활발히 진행되고 있습니다. 체내 삽입형 공간에는 다음과 같은 이슈들이 있습니다: (1) 장기와 조직의 크기와 모양이 개인별, 성장 단계별로 다양하고, (2) 근육, 신경 등 조직이 밀집되어 있어 여유 공간이 제한적이며, (3) 복잡한 3차원 입체 구성 요소로 배열된 공간이라는 도전적인 조건을 가지고 있습니다. 또한 인터페이스 전극을 따로 두거나 커프 전극처럼 연결하는 과정에서 전극의 면역학적, 기계적 문제들이 발생하기도 합니다. 이 이슈를 극복하기 위해서는 복잡한 신체 표면에 맞게 전극 부분과 더 나아가 디바이스 본체를 모두 맞춤 제작하는 것이 중요해집니다. 또한 제한된 공간에 전자소자를 효율적으로 패키징하기 위해서는 공간 활용을 최적화하는 것이 중요하기 때문에 3축의 자유도를 가진 제작 기술이 요구됩니다. 따라서 적층 제조를 활용하여 3차원 공간 내에 데이터 기반의 voxel화된 전자 재료를 구성하면 전자 부품을 맞춤형 형태로 통합할 수 있는 잠재력이 매우 높습니다. 또한, 삽입형 전자소자의 영구 삽입 또는 제거 수술로 인한 감염이나 내부 손상에 대한 우려를 해결하는 것이 중요합니다. 따라서 이러한 장치는 작동 수명이 다한 후 생분해되는 것이 필요합니다. 본 연구에서는 말초 신경에 삽입해 부상을 치료할 수 있는 무선 전기 치료 기능을 갖는 튜브형 전자약을 개발했습니다. 개발한 생분해성 voxel화된 전자 잉크를 바탕으로 모든 전자 부품 제작을 3차원 다물질 인쇄로 진행하였습니다. 중요한 점은 생분해성 voxel화된 반도체를 도체 및 유전체와 통합하여 무선으로 제어되는 단상 펄스를 생성하는 장치를 만들 수 있었으며, 이는 생의학 응용 분야에 대한 치료 효과에 대해서도 결과를 보여주었습니다. 소동물과 대동물에서 생체 내 적용 적합성을 평가하고, 치료 효과를 확인하고 실제 기능 회복에 미치는 영향을 평가하는 등 생물학적 검증을 통해 연구 결과의 유효성을 확인했습니다.

PG5A-24 | 열처리 온도에 따른 1.5mol% 이트리아 안정화 지르코니아 세라믹스의 소결 물성

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지르코니아 세라믹은 내식성, 화학적 안정성 등 기계적 물성과 심미성이 우수하여 치과용 임플란트 소재로 사용되고 있다. 본 연구에서는 높은 파괴인성을 나타낸다고 알려진 1.5mol% 이트리아 안정화 지르코니아를 열처리 온도별로 치밀체를 제작하여 소결 물성을 분석하고, 치과용 임플란트 소재로서의 적합성을 살펴보고자 하였다. 분석용 시편은 1.5Y-TZP 분말을 디스크 형태의 시편으로 성형한 다음, 1200~1350℃ 영역에서 각각 2시간씩 소결하여 제작하였다. 소결 후, 소결 밀도 측정, XRD 상분석, SEM에 의한 미세구조 분석을 실시하여 상관성을 분석하였으며, 경도 측정으로 기계적 물성을 살펴보았다. 분석 결과, 1200~1300℃의 열처리 온도 구간에서는 상대밀도가 99.5%

이상인 고밀도 소결체가 제작되었고, 경도도 비교적 높은 1100 Hv 이상의 값을 나타내었다. 1350℃에서 열처리한 시편에서는 입자크기가 상대적으로 크게 나타났으며, 정방정상 입자뿐만 아니라 단사정상 입자도 다량 존재하였다. 이에 경도 값이 다른 시편에 비해 약간 낮은 값을 보였고, 미세구조 분석에서도 일부 미세균열이 관찰되었다. 분석 결과를 종합하여 판단한 결과, 1250℃와 1300℃에서 열처리한 시편이 치과용 임플란트 소재로의 적용이 가능한 것으로 사료되었다.

PG5A-25 | Preparation of Different Composition of Bioactive Glasses through Melt-milling Process

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In this study, we report the preparation of bioactive glasses (BGs) using a melt milling process with different compositions. Four different compositions were prepared, namely 45S BG ($45SiO_2$-$24.5Na_2O$-$24.5CaO$-$6P_2O_5$) and 53S BG ($53SiO_2$-$23Na_2O$-$20CaO$-$4P_2O_5$), 45S BG ($45SiO_2$-$6.5Na_2O$-$24.5CaO$-$6P_2O_5$-$5MgO$-$12K_2O$) and 53S BG ($53SiO_2$-$6Na_2O$-$20CaO$-$4P_2O_5$-$5MgO$-$12K_{2O}$) were synthesized from six components. The characterization of the BGs was demonstrated by ICP-OES, FE-SEM, XRD, PSA, UTM and cell viability. The compositional ratios of the BGs are 45S BG (Si21.94-Na17.83-Ca17.73-P2.61), 53S BG (Si24.10-Na15.24-Ca13.84-P1.63), 45S BG (Si21.56-Na8.65-Ca20.45-P2.77-Mg7.17-K13.05) and 53S BG (Si24.70-Na4.41-Ca14.41-P1.88-Mg2.27-K8.1), respectively. The grain size of the BGs was in the range of 10-20 μm or less by FE-SEM, and the grains exhibited a polygonal shape. The compressive strengths of the BGs were 25.1 MPa, 31.1 MPa, 35.6 MPa and 41.1 MPa, respectively, corresponding to four components of 45S BGs and 53S BGs and six components of 45S BGs and 53S BGs. In the cytotoxicity evaluation, all four BGs showed cell viability of more than 80%, especially the six-component BGs showed cell viability of more than 90%. In conclusion, the six-component BGs showed superior results in both mechanical properties and cell viability compared to the four-component BGs.

PG5A-26 | Enzymatic Hydrolysis and Acylation with CalB and CalB@NF Immobilized by Magnetic nanoparticles

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This study reports the preparation of the Candida antarctica lipase B (CalB) enzyme and nanofructosome encapsulated CalB (CalB@NF) immobilization on silica-coated magnetic nanoparticles (Si-MNPs) and demonstration for rapid enzymatic hydrolysis and acylation against p-nitrophenyl butryate (p-NPB) and benzyl benzoic anhydride, respectively. Various enzyme kinetic parameters (i.e., K_m, V_{max}, and K_{cat}) were calculated from the Michaelis–Menten equation and Lineweaver–Burk plots. The stability evaluation was assessed as a function of the number of reuse and different pH and temperature values. Finally, the benzyl benzoate was analysis and the acylation conversion of with all four samples were calculated.

PG5A-27 | Thermo-responsive Polymer grafted Silica Encapsulated CaP Microspheres for Time-delayed Drug Delivery System

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This study reports the time-delayed drug delivery system with thermo-responsive polymer grafted silica encapsulated calcium phosphate (CaP) microspheres through the photopolymerization with poly (N-isopropylacrylamide) (PNIPAm). The CaP microspheres were prepared by precipitation of the diammonium hydrogen phosphate and calcium nitrate, and then silica encapsulation was performed as a function of the concentration of TEOS. Thermos-responsive PNIPAm was grafted on the PNIPAm@SiO_2@CaP microspheres by using 3-(methacryloxy) propyl trimethoxysilane (MOP) as a silane coupling agent to introduce double bond onto SiO_2@CaP microspheres and the radical copolymerization of MOP- SiO_2@CaP microspheres and NIPAm monomers. Furthermore, the thermo-responsive polymerization with cross-liking agents and initiators such as PNIPAm, N,N'-methylenebisacrylamide (MBA), potassium persulfate (KPS) and sodium metabisulfite on SiO_2@CaP microspheres. To obtained the time-delayed drug release profiles as a function of temperature between 25°C and 37°C, two kinds drugs of doxorubicin (DOX) and indomethacin (IMC) were loaded in CaP and PNIPAm@SiO_2@CaP, respectively. The release of DOX in the CaP microspheres was more slowly diffused than that of IMC in the PNIPAm layer because the silica layer is as a release barrier. Moreover, the time delayed release profile of ALD was obtained for 12 hours.

PG5A-28 | 스마트 콘택트렌즈를 이용한 동물 모델의 혈당과 눈물당의 상관관계 분석

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Tear is emerging as the one of the most promising body fluids for monitoring health conditions and many studies are underway to measure the tear glucose level through various biomedical platforms including contact lenses. For these platforms to be reliable for diagnosing diabetes, it is essential to clarify the correlation between blood glucose and tear glucose which remains controversial. However, previously reported studies regarding smart contact lenses were operated only at specified time which is non-continuous and have failed to identify the exact correlation. Herein, we present an in-depth investigation of the correlation between blood glucose and tear glucose. Our smart contact lenses are capable of continuous and compact measurements which enables exact comparative analysis. The developed smart contact lenses were applied to animal models for authentic clinical investigation of the correlation. This approach can offer unprecedented prospects for applications of the advanced biomedical platforms in further clinical trials.

PG5A-29 | 투명 디스플레이 활용을 위한 높은 해상도의 전기 자극 기술 액추에이터 개발

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Haptic devices are pivotal in fields like rehabilitation, virtual reality, and touch panels. While vibrotactile technology prevails, limitations in size, resolution, and materials have led to the emergence of electrotactile technology, driven by electrical stimulation. Our new transparent electrotactile device, designed with a 2 mm gap to match fingertip sensitivity, stimulates skin mechanoreceptors for varied tactile sensations. This technology employs diverse voltage and frequency ranges to activate different receptors. Cognitive experiments on 10 individuals showcased perceptible low-voltage stimulation (~10V), with frequencies (10-300Hz) inducing sensations like vibration, tapping, hardness, and pain. Evidenced by nerve signal transmission to the brain, the device demonstrates efficacy. It holds potential in transparent displays, prosthetics, and VR/AR tactile interfaces, promising enhanced applications across industries.

PG5A-30 | Comparative electrophysiological analysis of retinal model organisms with high precision 3D liquid metal electrodes

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The retina, an intricate tissue comprising distinct cellular layers, plays a pivotal role in facilitating high-resolution vision. While retinal organoids serve as valuable tools for histological analysis at the cellular level, murine models offer insights into neurophysiological aspects of retinal functionality. Nonetheless, inherent disparities between these models and the human retina necessitate the comprehensive electrophysiological comparisons alongside histological analyses to ensure research validity. Herein, we demonstrated multielectrode array (MEA) with minimally invasive soft 3D recording electrodes using liquid metal. By printing the liquid metal using 6-axis printing stage, the pillar-shaped 3D liquid metal electrodes were fabricated with high precision in height, allowing the specific cell targeting in retinal model organisms. Our study not only elucidates the potential for refined model selection in biological inquiry but also envisions the implementation of soft 3D MEA for biomedical devices.

PG5A-31 | 뇌 오가노이드의 전기 생리학적 특성 분석을 위한 액체 금속 3D 미세 전극 어레이

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Cerebral organoids have emerged as a powerful tool for a comprehensive understanding of human brain development and disorders. Conventional organoid analysis methods rely on surface signals that propagate through culture media, and characterization using rigid probes damages organoids due to slicing or penetrating procedures. Here we introduce a 3D microelectrode array featuring micropillar electrodes made of liquid metal. This innovation allows for the stable, long-term monitoring of electrophysiological signals from the intra-organoid interface. The dimensions of these micropillar electrodes can be conveniently adjusted using our straightforward direct-printing technique. The intrinsic softness of the electrode material enables long-term repetitive measurement to identify neuronal circuitry without degrading the condition of the organoid. Therefore, we can delve into the development of electrophysiological characteristics and networks in tandem with organoid maturation. This valuable information greatly enhances our comprehension of neural network traits during brain growth.

PG5A-32 | Real-time Pressure Mapping of Brain Organoids by Active-Matrix Array of Field-Effect Transistor

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Brain organoids increase in size as time progresses. Remarkably, at the end of their functional lifespan, necrosis initiates from the core, resulting in a reduction in the central density of these brain organoids. Therefore, it is meaningful to inspect their core condition for the characterization of their age. Conventionally, the examination of organoid cores has been conducted using a confocal microscope. However, this approach tends to be inadequate since optical characterization fails to provide a comprehensive understanding of the organoid's internal structure. Herein, we developed a pressure sensor based on an active-matrix array that enables continuous monitoring of brain organoids by sensitively detecting their subtle weight variations. Through the outputs acquired from individual sensor channels, we can generate a 2D mapping image that illustrates the pressure distribution across the brain organoids. This spatial distribution correlates to the core density, which serves as a reliable indicator of the organoids' overall condition.