PG5B : 바이오 세라믹스

PG5B-1 | Magnetic Anisotropy Engineering of Nanoparticles for Multi-Channel Magnetothermal Brain Stimulation

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One of the magnetogenetic techniques, magnetothermal stimulation, can non-invasively stimulate deep brain regions and help treat brain-related diseases such as Parkinson's disease. This technique typically uses magnetic nanoparticles (MNPs) as energy transducers, which generate heat by magnetic fields and activate or inhibit specific cells or tissues by the generated heat. However, applying multichannel in vivo is difficult and efforts are ongoing to optimize nanoparticles to achieve multiple stimulation. In this study, we aim to achieve multiple stimulation by magnetic anisotropy engineering. We synthesized MNPs doped with magnesium, manganese, and cobalt with sizes ranging from 5 to 15 nm and controlled the composition and size of MNPs to manipulate their magnetic anisotropy. The control of magnetic anisotropy enables the control of resonance frequency of MNPs. This enables the achievement of multiplexed stimulation by controlling the difference in resonance frequency. We confirmed the possibility of multiple channels by measuring the temperature-time plot of three different MNPs. Therefore, this study is expected to contribute not only to multiple stimulations but also to the development of diverse and effective applications, including sequential activation and multi-region stimulation.

PG5B-2 | Mg-Zn-ZnO 복합소재 제조 방법과 기계적 특성과 생분해 특성에 대한 연구

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아연 및 아연 합금은 생체 적합성과 생분해성이 우수하여 잠재적 BM 재료로 많은 연구가 진행되고 있다. 산화아연은 아연 금속과 산소가 결합한 산화물로 세라믹으로 분류되고 인체 내 독성이 없어 의료용품 및 치과의술용품 분야에 적용되고 있다. 대부분의 아연 합금은 기계적인 특성과 생분해 속도가 BM 재료로 사용되기에 부적합하다. 따라서 본 연구에서는 아연 합금을 BM 재료로써 적합한 기계적인 특성과 생분해 속도를 가지기 위하여 산화아연을 혼합한 아연-마그네슘-산화아연 복합소재를 제조하였다. 아연-마그네슘-산화아연 복합소재 제조를 위하여 용융된 아연에 4 wt % Mg와 3 wt % 산화아연을 투입하여 혼합하였다. 아연-마그네슘 합금에 혼합된 산화아연 형상을 관찰하기 위하여 전계형 주사전자현미경(FE-SEM)을 사용하였다. 기계적 특성을 평가하기 위하여 ASTM standard E384-99 조건하에 Mitutoyo HMV 200 micro-hardness tester를 사용하였다. 생분해 특성을 확인하기 위하여 Bio-degradability test를 진행하였다. micro-hardness test와 Bio-degradability test 결과 아연-마그네슘 합금에 비해 산화아연이 함유됨에 따라 경도가 증가하였고 생분해 속도에서는 산화아연 함유됨이 생분해 속도에 영향을 미치지 않았다.

PG5B-3 | Electrochemical immunoassays using diffusion layer dispersed microelectrode

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In this study, a band-type microelectrodes array with controlled diffusion layers was presented for electrochemical immunoassays. The diffusion layer refers to a region on the electrode surface where concentration gradients occur during the redox reaction of the target molecule. To control the diffusion layer, a microelectrode array with same electrode area and size was fabricated, and the distance between the electrodes was adjusted. To estimate the properties of the electrodes, cyclic voltammetry analysis was performed using potassium ferricyanide and TMB as a model redox couples. In addition, the diffusion layer shape change and concentration profile according to the distance distribution between electrodes were compared through FEM simulation. Despite the same electrode area and size, the redox current density for the target molecule increased as the distance between the electrodes of the microelectrode array increased. These results indicate that even if the electrode size and area are the same, dispersing the diffusion layer by adjusting the distance between the electrodes can affect the characteristics of the microelectrode. Finally, amperometric analysis of target molecules was performed using diffusion layer-controlled band-type microelectrode arrays.

PG5B-4 | 비효소 글루코스 센서 응용을 위한 $NiCo_2O_4$ 나노구조체 합성 연구

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혈당 수치는 사람의 신진대사 및 생리적 상태 등의 정보를 제공하는 대표적인 지표로서 당뇨병, 심혈관 질환 및 비만 등 심각한 건강 문제를 예방하기 위해 정기적으로 모니터링 하는 것이 중요하다. 최근에는 혈당 수치를 파악하기 위해 전류 측정을 기반으로 하는 글루코스 센서에 대한 많은 연구들이 진행되고 있는데 온/습도 등 주변 환경에 민감하고 상대적으로 낮은 출력 전류 농도를 나타내는 효소기반 전극 보다 비효소식 전극을 활용한 센서 개발에 관심이 증가하고 있다. 특히, 전이금속기반 화합물은 글루코스

에 대한 높은 Catalytic Activity를 나타내는 특성으로 인해 기존 귀금속을 대체하기 위한 대표적인 소재군으로 주목받고 있으며, 그 중 $NiCo_2O_4$ 의 경우 우수한 안정성과 글루코스 검출을 위한 전기활성도를 향상시키는데 추가적인 상승 효과를 나타낸다는 연구 결과가 보고되고 있어 비효소 기반 전기화학적 글루코스 센서로의 활용이 기대되고 있다. 본 연구에서는, Ni/Co의 비율, 수열반응 및 열처리 시간을 공정 변수로 설정하여 비효소 글루코스 센서 응용을 위한 다양한 비표면적을 지닌 $NiCo_2O_4$ 나노구조체를 합성하였다, 전기화학기반 CV 측정을 통해 모든 샘플에서 글루코스에 대한 전류 반응이 나타난 것을 확인하였으며, 비표면적이 넓을수록 충분한 산화반응 면적이 확보되어 민감도 및 안정성 또한 우수한 것으로 나타났다.

PG5B-5 | TiO_2 Nanotube Array without Coffee Ring Effect for Quantitative Laser Desorption/Ionization Mass Spectrometry

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Quantitative analysis using LDI-MS has been limited because of the nonuniform distribution of analytes caused by the “coffee ring effect”. In this study, a TiO_2 nanotube array with hydrophilic dot patterns surrounded by hydrophobic areas (HB/HL-patterned TiO_2 NTA) is presented to distribute analytes uniformly as well as to concentrate them within a sample spot. Suppression of the coffee ring effect is experimentally elucidated in terms of a capillary penetration of analyte solution into the selectively permeable NTA. The feasibility of HB/HL-patterned TiO_2 NTA for quantitative LDI-MS is demonstrated using two types of sepsis biomarkers, lysophosphatidylcholine 16:0 (LPC 16:0) and LPC 18:0. Further, LDI-MS based on the HB/HL-patterned TiO_2 NTA matrix is applied to the medical diagnosis of sepsis with the sera from sepsis-negative and -positive groups. These results reveal that the LDI-MS based on the HB/HL-patterned TiO_2 NTA matrix has the potential to be a practical approach for sepsis diagnosis.

PG5B-6 | Laser-Induced Surface Reconstruction of Nanoporous Au-Modified TiO_2 Nanowires for In-Situ Performance Enhancement in Laser Desorption and Ionization

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Fundamental understanding of the substrate properties is crucial for the design and development of an efficient laser desorption/ionization (LDI) matrix. Herein, we develop a nanoporous Au-modified TiO_2 nanowires (npAu-TNW) hybrid for the enhanced LDI-MS performance. Its origin is investigated based on hybrid matrix properties including photo-thermal conversion and electronic band structure. Notably, we obtain a further improvement in npAu-TNW than in pristine TNW and non-porous Au nanoisland-modified TNW (Au-TNW) hybrid, which is attributable to the laser-induced surface restructuring/melting phenomenon. Surface restructuring/melting occurs noticeably in the npAu by laser exposure through efficient photo-thermal conversion of the highly porous npAu, which in-situ promotes internal energy transfer from the npAu to the analyte, facilitating desorption. Moreover, the npAu structural changes distorts the adjacent TNW lattice, introducing trap states inside the bandgap and thereby enhancing the ionization. Ultimately, the high LDI-MS performance based on the npAu-TNW hybrid matrix is demonstrated by analyzing neurotransmitters.

PG5B-7 | Synergistic Effect of Heterostructure in Au Nanoislands/TiO_2 Nanowires for Efficient Ionization in Laser Desorption/Ionization (LDI) Mass Spectrometry

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A combination nanostructured matrix with metal Au nanoislands and semiconductor TiO_2 nanowires is presented to enhance both desorption and ionization efficiency in laser desorption/ionization (LDI) mass spectrometry. The heterostructure of Au nanoislands on TiO_2 nanowires was fabricated via (1) TiO_2 nanowire synthesis through a modified wet-corrosion method and (2) Au nanoisland formation through thermal annealing of a sputtered Au layer on the TiO_2 nanowires. Herein, the synergistic effect of this heterostructure for highly efficient ion production was experimentally elucidated in terms of the formation of high temperature on the surface of Au and the creation of a Schottky barrier at the Au-TiO_2 interface. Finally, four types of immunosuppressors were analyzed to demonstrate the improved ionization performance of the heterostructure for LDI mass spectrometry.

PG5B-8 | Top-down processed TiO_2 Nanowires for Quantitative Analysis of Small Molecules by LDI-TOF MS

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MALDI-ToF mass spectrometry has various advantages compared to other analytical methods including easy sample preparation, sensitive detection (< fmol), and a wide detection range up to 500 kDa. However, MALDI-ToF MS has a limitation with respect to quantitative analysis as well as in analysis of low molecular weight compounds due to intense chemical noise (background) from the organic matrix. In this study, we fabricated TiO_2 nanowire target plate for MALDI-ToF MS to eliminate matrix noise, and to detect small biomolecules. TiO_2 nanowires were synthesized by wet corrosion process. SEM and TEM measurements revealed the morphology of nanowires. The crystal structure was determined by XRD and Raman spectrometry. The feasibility of detecting small molecules by TiO_2 nanowire chip was demonstrated with various biomolecules. Quantitative analysis of glycine, arginine, glutamic acid, proline was carried out and limit of detection was 10 pM for glycine, arginine, glutamic acid, and 100 pM for proline.

PG5B-9 | SiO_2 Aerogel-based Nanoporous Combi-matrix for LDI-MS in Clinical Diagnosis of Cancer

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Silica aerogels have received attention for its high porosity, low thermal conductivity, and low density. In this study, SiO_2 aerogel was applied to the MALDI-TOF MS as matrix additives for a “combi-matrix” on quantitative analysis of dodecanoyl-L-carnitine (DC), which is known for a colon cancer biomarker. The combi-matrix showed the removal of noise signals from fragmented organic matrices. The optimal ratio of organic and inorganic matrix components for combi-matrix was tested under diverse matrix ratio. Quantitative analysis on DC conducted on wide concentration range and its validity was confirmed by fluorescence distribution image, and reproducibility test. Furthermore, the origin of noise reduction and quantitative signal acquisition was identified by DSC analysis on combi-matrix system. Silica aerogel induced a decrease in thermal conductivity, and an organic matrix crystal size confinement. Finally, the colon cancer biomarker, DC, was quantitatively analyzed by the combi-matrix. The cut-off level of DC in serum was obtained using healthy volunteers and cancer patients for medical diagnosis of colon cancer.

PG5B-10 | 유사 망막 설계를 위한 광반응성 신경 회로

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망막은 빛 자극에 반응하여 시신경을 통해 뇌로 신경신호를 발산하는 시각기관입니다. 이 과정을 해석하기 위한 실험용 플랫폼을 설계하였습니다. 인간의 유전정보를 활용해 인공 광수용체 단백질과 신경세포를 제작하는데 성공하였으며, 2종의 샘플에서 각기 다른 색깔의 빛에 대한 반응성을 검증하였습니다. 생체적으로 신경자극의 전달 경로부터 광학적으로 빛이 망막에서 투과되고 진행하는 과정을 모사하였습니다.

PG5B-11 | Mechanical properties of polymer composites incorporating hydroxyapatite for spinal implant materials

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Hydroxyapatite (HA) is a bioceramic material capable of growing calcium phosphate layers, the main component of human bones, on its surface. Therefore, HA has been incorporated into polymer composites to render them bioactive. For polymers to be used as implants, it is necessary that their bioinertness is overcome to promote bone regeneration. However, owing to weak interfacial affinity between HA and polymer matrix, HA tends to aggregate within the composites, thereby diminishing their mechanical strength. This study thus aimed to modify HA using two distinct approaches. Firstly, the surface of HA was treated with silane coupling agent to enhance its affinity towards the polymer matrix. Secondly, HA was modified morphologically, synthesizing HA nanofiber with high aspect ratio to improve the mechanical properties. As the matrix, polyetheretherketone was chosen, and carbon fiber was additionally incorporated for reinforcement. The mechanical strength and bioactivity of the composites with modified HA were characterized.

PG5B-12 | Preparation of sub-micro bioactive glasses by sol-gel process

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This study reports synthesis of three type of sol-gel bioactive glasses (SG BGs) such as SG 45S BGs, SG 53S and SG 58S BGs. SG 45S BGs and SG 53S BGs consist of a total of four components (SiO_2, CaO, P_2O_5, Na_2O), while SG 58S BGs is composed of a total of three components (SiO_2, CaO, P_2O_5). BGs produced through

the sol-gel process require less heat during the manufacturing process compared to BGs produced through melt-milling, making mass production easier and resulting in smaller particle sizes. The Characterization was demonstrated using a ICP-OES, EDS, FE-SEM, TEM, DLS and XRD. ICP analysis results, The composition ratios (wt.%) of SG BGs are SG 45S BGs (SiO_2-44.3 wt.%, Na_2O-25.6 wt.%, CaO-32.9 wt.%, P_2O_5-2.4 wt.%), SG 53S BGs (SiO_2-52.2 wt.%, Na_2O-17.3 wt.%, CaO-12.8 wt.%, P_2O_5-6.3 wt.%) and 58S BGs (SiO_2-58.2 wt.%, CaO-33.7 wt.%, P_2O_5-5.9 wt.%), respectively. DLS analysis revealed the particle sizes of Sol-gel 45S, 53S, and 58S bioactive glasses as 311 nm, 301 nm, and 210 nm, respectively. XRD patterns of SG 45S BGs and SG 53S BGs are seen at 26.7 °, 33.6 ° and 48.6 ° corresponding to the (211), (024) and (404) planes consistent with Combeite (JCPDS#01-077-2189). Furthermore, the biocompatibility was assessed through the Cell Viability Test.

PG5B-13 | 솔젤법을 이용하여 울라스토나이트 생체소재로 코팅한 Ti-6Al-4V합금의 표면 특성

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생체소재용 실리케이트계 세라믹스는 인체 삽입 시 표면에서 Ca 및 Si 이온을 방출하며, 방출 이온들은 골아세포의 증식 및 전도를 촉진하여 골 형성 및 임플란트와의 골결합을 유도하게 된다. 본 연구에서는 실리케이트계의 대표적 생체소재인 울라스토나이트를 솔젤법으로 합성한 후, 불활성 임플란트 소재인 Ti-6Al-4V 합금의 표면에 코팅시켜 기판소재의 골 형성능 및 골결합 특성을 향상시키고자 하였다. 졸 합성을 위한 출발원료로는 TEOS와 질산칼슘 수화물을 사용하였으며, 각각의 용액을 제조한 후 혼합, 교반, 반응 과정을 통하여 울라스토나이트 졸을 합성하였다. 기판 표면의 코팅층은 합성된 졸을 기판 위에 적하시킨 다음 스핀코팅법에 의해 형성하였으며, 이후 건조, 겔화 및 열처리를 통한 결정화를 거쳐 울라스토나이트가 표면코팅된 Ti-6Al-4V 기판을 완성하였다. 코팅기판의 표면 특성은 코팅조건에 따라 상 및 성분분석, 표면거칠기, 젖음각, 미세구조를 분석하였고, 코팅 형상 및 두께에 따른 in vitro 생체물성 변화를 고찰하였다. 실험결과, 1000°C~1150°C온도구간에서 열처리한 코팅시편의 표면에서는 울라스토나이트 상이 두루 관찰되었으며 비교적 균질한 코팅층이 형성되었다. 또한 SBF용액 내에 코팅시편을 침적시킨 경우, 코팅한 시편에서는 기존 기판에 비하여 하이드록시아파타이트 석출능이 크게 향상됨을 확인할 수 있었다. 결론적으로, 코팅 조건에 따라 코팅두께, 표면 미세구조, 거칠기, 젖음각 등이 변화하였는데, in vitro 시험 시 용해 및 하이드록시아파타이트 입자의 석출 특성(석출 개시시간, 석출정도, 석출모양)이 코팅두께에 크게 의존하였다.

PG5B-14 | Magnetically actuatable 3D liquid multi-electrode arrays for electrophysiological monitoring of brain organoids

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Brain organoids have emerged as a miniaturized substitute for the human brain as they recapitulate the functionality of three-dimensional (3D) neural network circuits. Existing devices to detect intra-organoid signals require either the section of organoids or the insertion of rigid electrodes, which curtails the 3D cellular organization of the organoids. Also, a restricted number of electrodes in fixed positions has disturbed the precise analysis in the 3D spatial scope of the organoids. Herein, we present a magnetically actuatable 3D liquid multi-electrode array (MEA) by high-resolution 3D printing of biocompatible metals for electrophysiological monitoring of brain organoids. The flexibility of these 3D liquidous electrodes enables magnetic control in the position of the electrodes, which multiples the density of recording sites with an identical number of electrodes. High-resolution neural network mapping of intra-organoid signals through a multi-spot detectable MEA is a promising method to examine the electrophysiological volumetric network of brain organoids.