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Two-dimensional nanomaterials as emerging pseudocapacitive materials

Park SK, Nakhanivej P, Park HS

Abstract - Supercapacitors have attracted significant attention as energy storage devices owing to their high power density, high charging rate, and long cycle life. However, they possess low energy density, which limits their practical applications. To address this issue, various high-capacitance materials, such as transition metal oxides and conducting polymers, have been investigated. Recent pioneering studies have described the emergent pseudocapacitance in twodimensional (2D) nanomaterials, which are of significant interest because of their unique structure, remarkable physical properties, and tunable surface chemistry. Through this brief review, we present our contributions to this new class of pseudocapacitive 2D nanomaterials: oxidized black phosphorous, transition metal dichalcogenides, and MXene. The surface-capacitive charge storage mechanism of 2D nanomaterials is understood through in situ spectroscopic and computational analyses. Moreover, the corresponding capacitive features and performances are maximized by nanostructuring, nanoarchitecturing, and compositional control.

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Electrospun nanofiber filters for highly efficient PM2.5 capture

Nam CW, Lee SK, Ryu M, Lee JW, Lee HM

Abstract - With the recent increase of concern on the health impact of air pollution, there has been growing interest in filtration technologies that can effectively remove fine inhalable particles (PM2.5) in the air with diameters that are generally 2.5 μm or smaller. Among various technologies presented, nanofiber-based filters provide A simple, but effective route to rapidly capture these fine particulate matters. In this review, we briefly introduce the health hazards associated with PM2.5 and highlight the importance of air filtration technology with particular emphasis on nanofiber-based filters prepared via electrospinning. Then, we summarize various fiber materials and additives utilized in electrospun nanofibers to enhance the filtration efficacy. Furthermore, we highlight some of the recent advances in the materials design of electrospun nanofiber filters for PM2.5 removal and discuss the current issues and future perspectives.

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Modeling and experiment of gas desorption of bubble column with an external loop in the heterogeneous flow regime

Im HJ, Park JI, Lee JW

Abstract - This work introduces an external loop to a bubble column and presents enhanced gas exchange in the heterogeneous flow regime. Gas exchange experiments under the same amount of gas input were carried out with varying gas velocity to understand the difference of bubble characteristic between the bubble column (BCR) and the bubble column with an external loop (BCR-EL). The observation of rise and descending velocity of bubbles in the BCR-EL showed that the fraction of bubbles passing the downcomer continuously increases with the incremental superficial gas velocity. A gas molecule in the liquid phase is desorbed by another gas molecule, and this gas exchange was assumed to be a phenomenon that a reactant in the liquid phase is converted to a product. To test the validity of the assumed gas exchange as a reaction in the experiments with the BCR-EL, a modeling study was performed using Fisher-Tropsch synthesis. It prevailed that the syngas conversion was higher in the BCR at the homogeneous flow regime, while the BCR-EL at the heterogeneous flow regime (above 0.08m/s) had higher syngas conversion than the BCR due to higher gas recycle to the downcomer.

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Inactivation of Escherichia coli and MS2 coliphage via singlet oxygen generated by homogeneous photosensitization

Kim TW, Kim HE, Cho JY, Kim HH, Seo JW, Lee JH, Choi JY, Lee CH

Abstract - The inactivation kinetics of E. coli and MS2 coliphage by singlet oxygen (1O2) were investigated in a homogeneous photosensitization system using Rose Bengal (RB) and visible light illumination (the Vis/RB system). The inactivation of E. coli and MS2 in the Vis/RB system was monitored over time with variations of several parameters such as pH, light intensity, concentration of RB, and the presence of dissolved oxygen. In addition, the concentration of 1O2 generated by the Vis/RB system was quantified using furfuryl alcohol under each microbial inactivation conditions. Based on the obtained results, the degree of microbial inactivation was quantitatively correlated with 1O2 exposure using the (delayed) Chick-Watson model. The Ct (concentration-time product) values of 1O2 required for 2 log microbial inactivation were found to be 1.3 × −4 mg · min/L for E. coli and 1.9 × −5 mg · min/L for MS2, respectively. The inactivation of E. coli exhibited an initial lag phase until 0.5 × −4 mg · min/L of Ct.

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Metal organic frameworks (MOFs): Current trends and challenges in control and management of air quality

Kumar P, Vejerano E, Khan A, Lisak G, Ahn JH, Kim KH

Abstract - Coordination polymers (CPs) are a unique class of polymers characterized by a molecular structure consisting of repeating metal centers linked by organic ligands in an infinite array connected through coordination bonding. In the last two decades, research interest in CPs, such as metal organic frameworks (MOFs), has grown rapidly owing to their exclusive advantageous properties (e.g., exceptionally high surface area, chemical and thermal stability, molecular functionality, porosity, electron mobility, thermal conductivity, and mechanical strength). In this study, we started with a basic question: Why and how are coordination polymers special and how do they differ from other classes of polymers? Next, we explored the value of unique and innovative CPs in line with the advent of design and synthesis approaches. We focused on the current trends and challenges of CPs/MOFs for application in the control and management of air quality. The intent of this review is to motivate development of CPs/MOFs that can be ultimately applied towards more efficient and effective technology as remediating and managing of the air quality. Ultimately, this review will help us open a new paradigm to pursue the future progress in polymers and materials science that targets specific applications in environmental engineering.

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Prolonged antimicrobial activity of silver core-carbon shell nanoparticles

Wang Z, Wang T, Hua A, Ma S, Zhang Z, Liu L

Abstract - Ag nanoparticles present good antimicrobial activity but with a potential toxicity to the cell, which limits the application. To address this issue, in this work, carbon-encapsulated sliver nanocapsules (Ag@C nanocapsules) were prepared by evaporating pure Ag ingot with the modified arc-discharge technique, and the Ag@C nanocapsules were acidified with nitric acid subsequently to facilitate the silver ion to release. Finally, Ag@C nanocapsules displayed a good and sustained antimicrobial activity against E. coli as a model of Gram-negative bacteria, due to the long-term release of sliver ions from Ag@C nanocapsules. The results obtained in this work indicate that the Ag@C nanocapsules may be a suitable nanomaterial for the bactericidal application.

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Analytical Solutions of Unsteady Reaction-Diffusion Equation with Time-Dependent Boundary Conditions for Porous Particles

Cho YS

Abstract - Analytical solutions of the reactant concentration inside porous spherical catalytic particles were obtained from unsteady reaction-diffusion equation by applying eigenfunction expansion method. Various surface concentrations as exponentially decaying or oscillating function were considered as boundary conditions to solve the unsteady partial differential equation as a function of radial distance and time. Dirac delta function was also used for the instantaneous injection of the reactant as the surface boundary condition to calculate average reactant concentration inside the particles as a function of time by Laplace transform. Besides spherical morphology, other geometries of particles, such as cylinder or slab, were considered to obtain the solution of the reaction-diffusion equation, and the results were compared with the solution in spherical coordinate. The concentration inside the particles based on calculation was compared with the bulk concentration of the reactant molecules measured by photocatalytic decomposition as a function of time.

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미세유체시스템 제작을 위한 3D 프린팅 방식 및 소재 별 표면특성 비교
Comparison of Surface Characteristics According to 3D Printing Methods and Materials for the Fabrication of Microfluidic Systems

배서준, 임도진

Abstract - 본 연구에서는 미세유체 시스템 제작에 적합한 3D 프린팅 방식 및 소재 별 표면특성 분석을 통해 각 응용 사례에 적합한 프린터 및 소재 선정에 가이드라인을 줄 수 있는 기초 연구를 수행하였다. 가장 보편적으로 사용되는 적층 방식과 해상도가 상대적으로 높은 광경화 방식에 대해 프린팅 방식과 소재에 따른 표면 특성을 살펴보았다. 적층 방식의 프린트물은 소재에 무관하게 후처리 전에는 친수성 특성을 보이나 아세톤 증기에 의한 후처리 후에는 소수성 특성을 보임을 확인할 수 있었다. SEM을 이용한 표면 조도 관찰을 통해 이러한 접촉각의 변화가 후처리에 의한 표면의 결 구조의 제거에 기인한 것임을 확인하였다. 광경화식 프린트물은 적층식 대비 친수성의 특성을 보였으나 소수성 코팅을 이용해 표면 개질이 가능함을 실험적으로 확인하였다. 두 프린팅 방식 중 투명한 재질이 요구되는 경우, 적층 방식은 투명한 시편을 만드는 것이 불가능함을 확인하였으며 광경화 방식의 경우 충분한 투명도가 확보됨을 확인하였다. 액적 접촉충전 현상에 기반한 디지털 전기천공 시스템의 electroporation chip을 광경화 방식으로 제작하였으며 성공적으로 전기천공을 시연함으로써 미세유체 시스템에 직접 적용이 가능함 또한 확인하였다.

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파상형 이온 선택 표면상의 전기와류 불안정성
Electroconvective Instability on Undulated Ion-selective Surface

이효민

Abstract - 이온 선택성 표면이 가지는 파상구조와 전기와류 불안정성 간의 전기동역학적 상호작용을 수치해석을 통하여 연구하였다. 유한요소법을 이용하여 전기장-이온 이동현상-유동장을 완전결합 해석을 하였다. 이를 통해 파상구조가 제공하는 전기와류 생성 기작인 Dukhin's mode의 유효성 및 역할을 제시하였다. Runinstein's mode와 경쟁관계에 놓이는 Dukhin's mode는 (i) 과한계 영역으로의 전이 전압을 낮춰주고 (ii) 혼돈계인 과한계 영역에서 전류를 비선형적으로 증가시켜준다. 또한, (iii) 전기와류 불안정성에서 발생하는 비효율적 혼합의 원인인 고주파수 Fourier 성분을 배제하여 전기와류의 혼합 효율을 상승시켜 준다. 결론적으로, 본 연구에서 제시한 기작은 전기투석, 화학전지 등의 이온 선택성이동현상 시스템에 대한 에너지 효율적인 기작으로 활용 가능할 것이다.