한국청정기술학회

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KSCT Spring Meeting and International Symposium

2021. 3.24(수) ~ 3.26(금)
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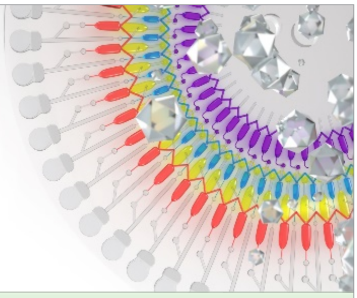
한국청정기술학회
The Korean Society of Clean Technology

2014-2024년 선도연구센터(ERC)

결정기능화 공정기술센터

Functional Crystallization Center (FCC)

센터장 : 경희대학교 화학공학과 김우식 교수



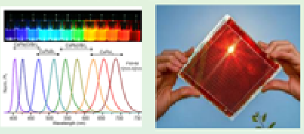
- 산업 니즈에 맞는 신기능성 복합결정 설계기술
- 규칙적 유동특성 기반 복합결정화 공정기술
- 첨단소재 제조기술 토탈솔루션 포트폴리오 구축

- 기능성 극대화 신규 결정 설계공정 및 물성 최적화 기술
- 규칙적 유동장에 최적화된 기능성 결정 설계기술
- 마이크로-매크로 통합 결정 기능화 플랫폼 공정기술

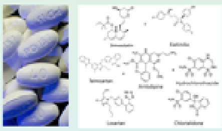
- 조립인자를 이용한 고기능성 결정 제조기술
- 규칙적 유동특성을 이용한 결정 기능화 공정기술
- 유동장 전산모사를 이용한 결정화 공정해석

- 결정의 기능성 증대를 위한 조립인자 제어기술
- 분자역학을 이용한 결정 모델링
- 규칙적 유동특성을 이용한 결정화 현상 제어기술

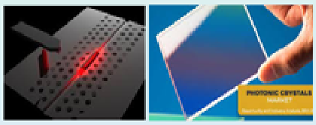
에너지 결정소재



활성의약물질 결정소재



광학 결정소재



에너지 촉매소재

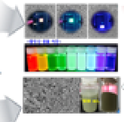
설계기술그룹 연구목표 자기조립 및 분자인식 기반 기능성 결정 설계 기술 개발

기능성 결정

- 기능성 유기 분자결정
- 하이브리드 나노결정
- 다차원 금속나노결정
- 다차원 무기 나노결정
- 다차원 반도체 나노결정

확장 가능한 설계

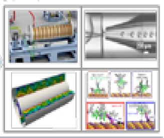
- 고재현성 합성 설계
- 고농도 합성 설계
- Scalable 합성 설계
- 친환경 합성 설계



활용분야

- 제약/의약품
- 태양전지/LED
- 광학결정(THZ)
- 연료전지/이차전지

공정기술그룹 연속공정



연구성과 요약

- SCIE총 260여편 (EES, Adv Mater, Adv Funct Mater 등)
- JCR<5% 40여편
- JCR<10% 110여편
- 기술이전: 12건 (기술료:약 13억원)
- 창업: 2건
- 특허등록: 70여건
- 특허출원: 130여건

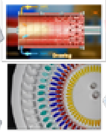
공정기술그룹 연구목표 규칙적 유동을 이용한 기능성 결정화공정기술 개발

규칙적 매크로 유동 기반 공정 기술

- 규칙적 매크로 유동 설계
- 결정 핵생성/성장 제어
- 결정 연속 생산공정기술

규칙적 마이크로 유동 기반 공정 기술

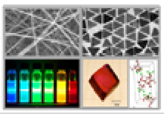
- 마이크로 유체 정밀제어
- 규칙적 마이크로 유동 생성
- High-throughput 결정화기



결정 기능성 예측 모델링 연구

- 규칙적 유동 특성 전산모사
- 분자 모델링 기반 성장 규명
- DFT 기반 결정 생성 최적화

설계기술그룹



연구성과 요약

- SCIE 총 290 여편 (Science, Nat Mater, EES, Adv Mater, Joule 등)
- JCR<5% 80여편
- JCR<10% 160여편
- 기술이전: 11건 (기술료 약 4억원)
- 사업화: 3건
- 특허등록: 50여건
- 특허출원: 100여건

http://fccerc.khu.ac.kr

경희대학교 KYUNG HEE UNIVERSITY · 고려대학교 KOREA UNIVERSITY · 아주대학교 AJOU UNIVERSITY · 인하대학교 INHA UNIVERSITY · CAU 중앙대학교 · KAIST · UNIST ULSAN NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

초저에너지 자동차 초저배출 사업단(SULEEV)

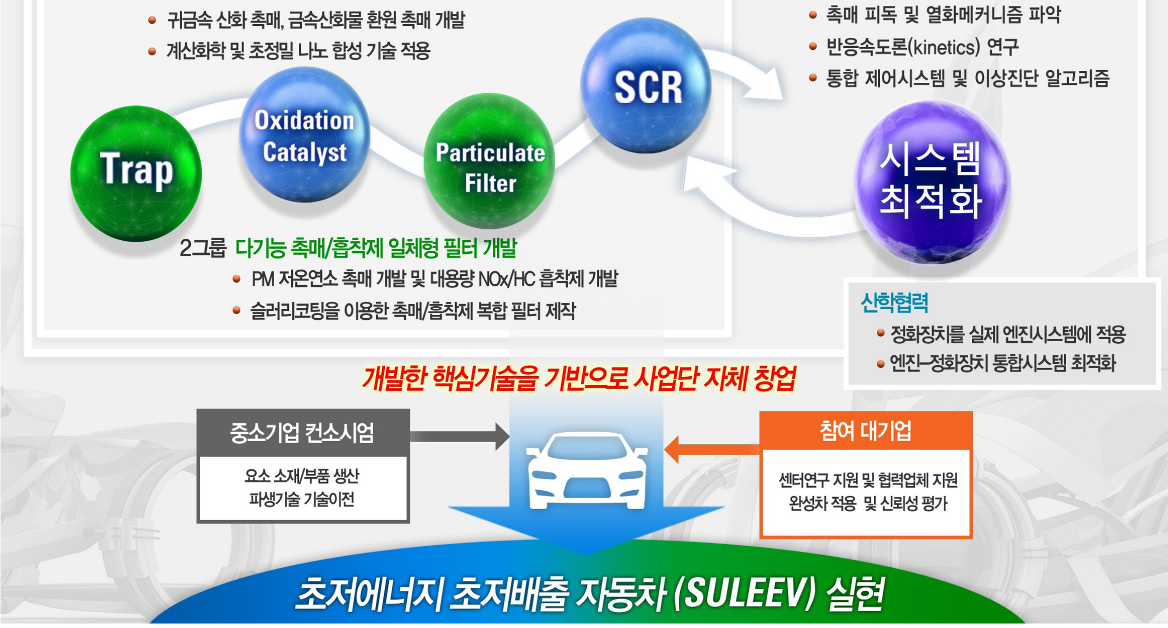
고려대학교
초저에너지자동차
KU SULEEV 초저배출사업단

이관영 교수
고려대학교 화공생명공학과

단장 인사말

과학기술정보통신부가 지원하는 기초연구사업분야 선도연구센터(ERC)사업에 초저에너지 자동차 초저배출 사업단(Super Ultra Low Energy and Emission Vehicle Center, SULEEV)이 선정되어 2016년 6월 출범하였습니다. SULEEV 사업단은 "초저에너지 자동차와 초저배출 정화시스템 기술의 상용화"를 목표로 융합연구를 수행하여 낮아진 배출가스 온도에서도 높은 정화 성능을 보이는 새로운 정화시스템을 개발하고 사업화할 것입니다. 앞으로도 SULEEV 사업단에 많은 관심과 격려 부탁드립니다.

사업단 구성



1그룹 **저온 고성능 산화/환원 촉매 개발**
- 귀금속 산화 촉매, 금속산화물 환원 촉매 개발
- 계산화학 및 초정밀 나노 합성 기술 적용

2그룹 **다기능 촉매/흡착제 일체형 필터 개발**
- PM 저온연소 촉매 개발 및 대용량 NOx/HC 흡착제 개발
- 슬러리코팅을 이용한 촉매/흡착제 복합 필터 제작

3그룹 **고효율 고내구성 자동차 촉매 시스템 개발**
- 촉매 피독 및 열화메커니즘 파악
- 반응속도론(kinetics) 연구
- 통합 제어시스템 및 이상진단 알고리즘

산학협력
- 정화장치를 실제 엔진시스템에 적용
- 엔진-정화장치 통합시스템 최적화

개발한 핵심기술을 기반으로 사업단 자체 창업

중소기업 컨소시엄
요소 소재/부품 생산
파생기술 기술이전

참여 대기업
센터연구 지원 및 협력업체 지원
완성차 적용 및 신뢰성 평가

초저에너지 초저배출 자동차 (SULEEV) 실현

주요 연구성과

- 본 사업단은 1단계 (2016년~2019년)에서 73건의 논문 게재, 85건의 국내외 특허 출원을 통해 우수한 연구성과를 발표함.
- 또한 5회의 국제 학술회의 개최, 100건의 대외 발표, 다수의 해외 대학 및 연구소와 공동연구 추진 등 세계적으로 활발한 학술 교류 활동을 진행하고 있음.

대표 특허

수열 안정성이 우수한 NH_3-SCR 반응용 촉매 개발 및 기술이전

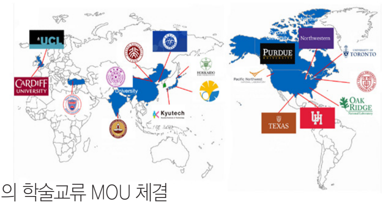
고온의 수열 조건에서도 우수한 활성을 유지하는 촉매 합성 기술을 개발하였으며, 해당 기술은 경제성과 촉매 수열 내구성 및 성능 측면에서 세계 최고 수준임을 인정받아 세계적 화학회사로의 기술이전을 추진중임

대표 논문

완전 고분산된 금속 ensemble 촉매를 이용한 삼원 촉매 반응 연구

100% 분산도를 갖는 Pt, Pd, Rh ensemble 촉매를 적용하여 세계 최고 수준의 삼원 촉매 반응 활성 및 900℃의 고온에서 수열 안정성을 확보하여, 촉매 분야 중 세계적으로 가장 권위 있는 학술지인 Nature Catalysis에 게재됨

해외 대학 및 연구소와의 공동연구



- 12건의 학술교류 MOU 체결
- 한국화학공학회, MCARE 등 국내외 관련 학술회의 내 심포지움 개최

현대자동차 저온 촉매 공동연구실

- 참여기업인 현대자동차와 ERC 사업단 연구 성과 실용화를 위한 공동 연구실 구성
- 사업단 1단계 기간 중 학교, 기업 연구소 등 다양한 장소에서 총 12차례의 세미나를 개최하여 정화 시스템 개발을 위한 연구 기술적인 교류 진행

Energy Human Resources Development
of Pukyong National University

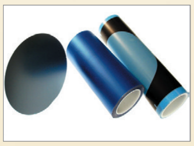
부경대학교
에너지수송체시스템개발 인력양성사업단

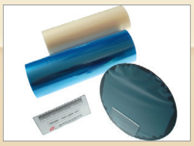
에너지인력양성사업단
(48547) 부산광역시 남구 365 부경대학교 용당캠퍼스 4공학관 209호
Tel 051. 629. 7938~9 Fax 051. 629. 6429

산업통상자원부
KETEP 한국에너지기술평가원
Korea Institute of Energy Technology Evaluation and Planning

산업용특수테이프
분야를 선도하는
화인테크놀리지

반도체용 점착 TAPE


DICING TAPE

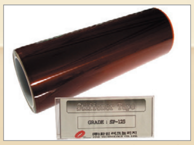

BACK GRINDING TAPE

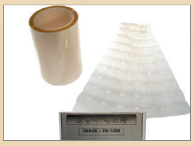

HEAT SEAL TAPE

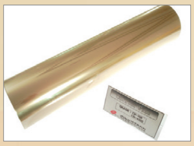

EMC MOLD CUTTING TAPE

FPC MATERIL


COVERLAY TAPE


STIFFENR TAPE(보강판)

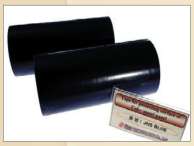

CARRIER TAPE


CARRIER TAPE

산업용보호 TAPE

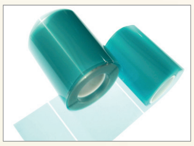

건축자재용 보호 TAPE

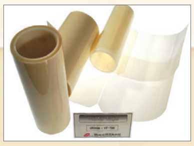

건축자재용 보호 TAPE


자동차 부품용 보호 TAPE


자동차 부품용 보호 TAPE

세라믹가공·발포용 TAPE





라벨스티커

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경남 양산시 어곡공단1길 10
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금호피앤비화학

금호폴리켐

LOTTE MCC

LOTTE CHEMICAL

CCMP

코팅기반 화학공정 연구센터

Center for Coating Materials and Processing

SMART OCEAN

(주)스마트오션

桓

ENGINEERING

재원산업주식회사

JAEWON INDUSTRIAL CO.,LTD.

Futureyes
퓨쳐아이스

(주)지와이티엔에스
G.Y Technology & Science

한국청정기술학회

e컨퍼런스

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한국청정기술학회
The Korean Society of Clean Technology

Greeting

—

인사말

한국청정기술학회

e컨퍼런스

KSCT Spring Meeting and International Symposium

존경하는 한국청정기술학회 회원 여러분!
안녕하세요? 반갑습니다.

여러 가지로 어려운 시기에 2021년 3월 24일부터 26일까지 춘계학술대회를 온라인 e컨퍼런스로 개최하게 되었습니다. 누구도 예상치 못한 코로나로 인하여 작년에 이어 올해도 비대면으로 학회를 운영하게 되었습니다. 이점 널리 양해해 주시길 바랍니다. 특히 올해는 학회의 운영 및 학술대회 수준향상을 위해 다각도로 노력하고 있으며, e컨퍼런스를 위해 발빠르게 온라인으로 결정하고 철저한 준비를 위해 최선의 노력을 다하고 있습니다.

매년 개최되는 학회이지만 올해 상반기에는 크게 청정일반, 청정공정 및 청정융합으로 구분하고 8개 부문위원회(바이오연료 및 소재, 오염저감, 청정소재 및 공정, 청정융합, 청정석탄, 탈황-탈질, 온실가스, 청정 용매)별로 운영될 예정입니다. 이번 학술대회에는 이사분들의 의견을 반영하여 학회에서 논문을 발표하는 연구자들의 연구력 향상, 연구의욕 고취 및 학회발전을 위해 논문상을 3종류로 분류하여 최우수논문상, 우수논문상 및 장려상을 수여하려고 합니다.

최근 들어 우리나라도 코로나 백신 접종을 시작했기 때문에 가능한 빠른 시일 안에 코로나 상황이 서서히 종식되어 예전과 같이 오프라인으로 춘계 및 추계학술대회나 학회 행사를 개최할 수 있는 날이 오기를 고대합니다.

상황이 좋아지면 올해 9월에 개최되는 추계학술대회는 대면으로 진행하려고 계획하고 있습니다. 오랜만에 대면으로 개최하는 학술대회이므로 다양한 주제와 참신하고 수준 높은 학회운영을 하려고 노력하고 있으므로 많은 회원 분들이 참석하셔서 좋은 의견과 만남의 장을 만들어 주시길 바랍니다.

이번 춘계학술대회는 e컨퍼런스로서 작년과 비슷하지만 보다 새로운 형식을 도입하려고 노력하였으며, 성공적인 개최를 위해서 회원여러분들의 적극적인 참여가 필요합니다. 회원분들께 여러 가지로 불편한 점에 대해 양해 말씀 드리며 일일이 동영상 촬영과 업로드의 협조를 부탁드립니다. 행사에 차질이 없도록 수고해 주신 이사진 여러분과 Hicomp사에 감사드리며, 그리고 학술대회를 위해 후원해 주신 여러 기업체에도 깊이 감사드립니다.

한국청정기술학회 학회장

변 헌 수

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청정공정

Stochastic optimization of a multi-feedstock bioethanol supply chain under multiple uncertainties

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The global goal to reduce dependence on fossil fuels and mitigate greenhouse gas emissions has resulted in focused on environmentally friendly and cost-efficient sustainable energy resource. Amongst various candidate, biomass have attracted much attention in recent years. Most of the current biofuels are produced from the grains of edible crops called first generation biofuels which can have detrimental effects on food security, induce deforestation and show poor energy balances. Focusing on cellulosic biomass (second generation biofuel) and microalgae (second generation biofuel) as feedstock are promising option for solving this issue.

Biomass supply chain is included various processes and each of them has uncertainty parameters. The most important parameters have uncertainty characteristics are: biofuel demand and biomass supply (biomass yield, harvest rate and biomass quality). In this work, based on our parameters and specific biomasses we address a multi-stage stochastic mixed integer programming of a biomass-based fuel supply network to deal with these two main uncertainties. A real case study is carried out to explore the applicability of the proposed model for South Korea.

바이오 숙신산의 탄소중립 타당성 검토

유 준, 딕슨 로피스 부경대학교, Lahore University of Management Sciences

Feasibility study of sustainable bio-succinic acid production

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Production of bio-succinic acid (bio-SA) from biomass has the potential to partially replace some petrochemicals, reduce climate change by capturing carbon dioxide, and provide a cleaner environment by managing waste streams. This study evaluates the economics, environmental impact, risk assessment, and optimal-processing route of bio-SA production from multiple feedstocks (first, second, and third generation), including (1) glucose, (2) corn stover, (3) glycerol, and (4) seaweed. A superstructure-based optimization model consisting of 39 processing alternatives with a technology-readiness level of 7-9 is developed, and the optimal topology for bio-SA production by maximization of the net present value under deterministic and stochastic conditions is identified. Once optimization is completed, the framework provides clear guidance for multi-criteria analysis, including the technical, economical, and environmental aspects of the biorefinery. The results indicate that glycerol is the first best feedstock and corn stover is the second, producing bio-SA at selling prices of 1.6-1.9 USD/kg and 1.7-2.0 USD/kg, respectively, through their optimal processing pathways. Saccharina japonica (seaweed) is less suitable for large-scale bio-SA production due to the high cost of seaweed and the inability of enzymes to hydrolyze alginate, which is one of the major carbohydrate fractions (25-30 wt%) of this feedstock. The environmental results indicate that the optimal pathway from glycerol is the most environmentally friendly process, followed by optimal processing pathways from substrates such as corn stover, glucose, and S. japonica.

Development of natural mineral based materials for removal of aqueous pollutants

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Since the environmental concern of aqueous pollutants has increased worldwide, much efforts have been made on the development of novel and environmental-friendly materials for decontamination of wastewater and groundwater. In this study, we developed natural minerals based remedial materials for removal of organic (i.e., trichloroethylene, TCE) and inorganic (Cr(VI)) pollutants in soil and groundwater. Various natural minerals were pre-tested for their reactivity towards target pollutants, dispersibility in the suspension, and mobility in soil column and natural zeolite was selected as the most promising natural mineral. The Fe and Fe/Ni dopped natural zeolites were prepared and used for removal of Cr(VI) and TCE, respectively. The developed materials showed an almost 100% of removal efficiency for both experiments with high mobility in soil column test. For Cr(VI) removal, Fe dopped natural mineral could reduce the Cr(VI) to Cr(III) via electron transfer from the dopped Fe, while TCE was reduced to non-toxic byproducts (i.e., ethylene and ethane) by Fe/Ni dopped natural zeolite. The results obtained from this study can provide a new insight that natural minerals could be used as supports for development of remedial materials, which possess the high reactivity and mobility under complex soil environment.

Acknowledgement

This research was supported by the Korea Environment Industry & Technology Institute (KEITI) through “Subsurface Environmental Management (SEM) Project”, funded by Korea Ministry of Environment (MOE) (2020002480006).

Catalyst Design by Atomic Layer Deposition Technique for Electrochemical Biomass Conversion

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The electrocatalytic conversion technology of biomass derived oxygenates such as glycerol presents a promising method of coproducing renewable chemicals and hydrogen in an electrochemical reactor system that uses oxidation chemistry and existing proton exchange membrane (PEM) technology to electrocatalytically convert oxygenates into value-added chemicals and hydrogen. Glycerol is a valuable byproduct in the production of biodiesel and fatty acids. Currently, global glycerol production (4.3 million metric tonne (Mt) per year) has exceeded the demand for glycerol (2.0 million Mt per year) in 2015. As excess glycerol increases, it is expected to progressively lower the price, thereby becoming largely available for glycerol derivatives. The electrocatalytic oxidation process of glycerol is a promising technology that can produce valuable chemicals such as dihydroxyacetone, glyceraldehyde, glyceric acid and glycolic acid by selective oxidation reaction and electrical energy by full oxidization reaction. Electrocatalytic glycerol oxidations have been reported with Pt, Pd and Au metal-based catalysts. However, only a few works have focused on changing and modifying the metal catalyst surface with precise, atomic-level controllable techniques for efficient electrocatalytic glycerol oxidation reaction. In this presentation we will introduce an efficient catalyst design strategy using an atomic layer deposition (ALD) method that allows us atomic level surface control of metal catalyst, enhancing the electrochemical glycerol oxidation performance.

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지속가능한 플라스틱: 공정 합성 및 기술경제성 평가

원 왕 연 경희대학교

Toward renewable plastics: process synthesis and technoeconomic analysis

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The utilization of lignocellulosic biomass for the production of bio-based plastic has increasingly received great attention for promising technology to mitigate environmental impact. 2,5-Furandicarboxylic acid (FDCA) is one of the promising renewable building block, which can substitute conventional petro-based terephthalic acid (TPA). This study presents the integrated process for the co-production of FDCA, furfural, and activated carbon from lignocellulosic biomass. Further, the proposed process is systematically assessed via a wide array of technoeconmic analysis. Once biomass is fractionated into its major derivatives (i.g., cellulose, hemicellulose, and lignin), each derivative is processed separately as follows: (1) dehydration of cellulose to 5-hydroxymethylfurfural (HMF), (2) oxidation of HMF to FDCA, and (3) dehydration of hemicellulose to furfural. To recover the target products as well as recycle the solvents, effective separation subsystem is designed and coupled with the reaction subsystem. In particular, heat exchanger network is composed to reduce utility consumption via pinch analysis. From the technoeconomic analysis, we determine the minimum selling price of FDCA as $1,380/ton, which is comparable to petro-based TPA ($1,445/ton), meaning that the bio-based FDCA has potential to substitute the petro-based TPA. The sensitivity analysis is conducted to point out the most influential economic and process parameters. Moreover, uncertainty analysis using Monte-Carlo simulation method is performed to reflect the risk and uncertainty associated with premature technology.

A Study on Site Allocation Modeling of Hydrogen Refueling Station

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Hydrogen is drawing an increasing attention as a source for sustainable energy source for transportation section. In order to establish hydrogen infrastructure for transportation vehicles with, a large number of Hydrogen Refueling Stations (HRS) should be constructed. However, it is financially burden to construct multiple HRS within a short period of time to meet all requirements. It is realistic to prepare gradual expansion plan in a systematic way for the maximal impact.

A new methodology to select the best site for HRS in this paper. At first, hydrogen demand at all potential sites of HRS is computed in advance. In the computation, various data such as population, area, population density, and number of hydrogen vehicles and other gasoline-based vehicles. Geographical Information System (GIS) were used. Those data were used to determine the location priority for HRS. Based on the estimated Hydrogen demand, the number of required HRS over multiple time periods was calculated. In this paper, the computation is conducted by using public data and map APIs for calculating distance and driving time between candidate sites. Using the number of HRS, a node-based location problem, P-median was estimated. To evaluate the satisfaction level of HRS location, it was visualized based on the average distance and the required driving time. The applicability of the proposed methodology is illustrated by a case of Korean metropolitan city of Ulsan.

The further research on HRS would be followed with the rising global interest on green transportation economy.

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청정 연료 생산을 위한 빛의 자유에너지 하베스팅

유 성 주 아주대학교

Harvesting Free Energy of Light for Renewable Photosynthesis of Fuels

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탄소 중립 에너지 미래를 위해 재생 가능한 자원을 에너지원으로 하는 청정연료 생산 기술 개발이 요구되고 있다. 재생 가능한 에너지 중 태양에너지는 무한한 매장량과 전기 또는 화학에너지의 형태로 직접 변환 및 저장이 가능하므로 지속 가능한 미래성을 제공한다. 이 발표는 과도기 단계에 있는 태양에너지 전환 및 활용 기술의 기초부터 발전 방안을 설명한다. 특히, 빛의 자유에너지가 강력한 전하 운반체의 형태로 수확되는 과정을 살펴본다. 예를 들어, 금, 은, 구리와 같은 금속 나노입자는 특정 주파수의 전자기 복사선과 강한 상호작용을 통해 집단적 전자 진동과 함께 국소적으로 크게 증가된 전자기장을 발생시킨다. 이 과정을 국소 표면 플라즈몬 공명이라 부르며, 플라즈몬에 의해 생성된 전하 운반체 또는 열에너지는 물과 이산화탄소와 같은 작은 분자들의 비자발적 산화환원반응을 촉진해 고밀도 에너지 연료 물질을 생산한다. 플라즈몬 유도 전하 운반체에 의해 기여되는 화학적 전위는 나노구조, 광자에너지 및 강도, 반응 매개체를 변화시킴으로써 향상될 수 있다. 향상된 전하 운반체의 화학적 전위 및 자유에너지는 다전자전달 과정을 통해 반응 속도를 촉진했으며, 특히 에너지 밀도가 높은 생성물로의 반응 경로를 형성하는 것으로 나타났다. 해당 반응 속도론과 메커니즘은 이론적, 실험적 반응 모델과 함께 설명된다.

저급자원 활용 합성가스 기반 청정 에너지 생산 기술

이 진 욱 고등기술연구원 플랜트엔지니어링센터

Clean Fuel Production Technologies based on Syngas from the Gasification of Low Grade Fuels

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우리나라의 경우, 에너지를 96% 이상 해외에서 수입하는 입장에서 에너지자원 자체를 확보하기 위한 지속적인 노력이 필요하다. 또한 전 세계적으로 생활의 질 향상 및 지구온난화에 대한 관심 등으로 청정에너지에 대한 수요가 대폭적으로 증가하고 있는 추세이다. 21세기에는 주요 에너지원으로서 천연가스, 전기 및 초청정유 등 청정에너지 자원이 대세일 것이다. 한편, 현재의 기술 수준은 에너지는 더 이상 자원이 아니라 기술로 정의되는 시대에 진입하여 지하에서 자원을 채굴하는 방식이 아닌 기존의 저급 또는 잉여 자원으로부터 가스화 및 변환 기술을 사용하여 청정 합성가스 및 고순도 수소를 생산할 수 있는 시대로 진입하고 있다. 합성가스는 생산 과정의 특성상 기본적으로 청정에너지이며, 원리적으로는 석탄 등 모든 유기물질로부터 생산이 가능하다. 합성가스의 주성분인 일산화탄소(CO)와 수소(H2)는 화학산업의 기초물질이므로, 천연가스가 부족한 지역에서 대체 청정가스로 활용이 가능하며, 합성가스를 생산하는 가스화 기술의 특상 상 CO2 대응에도 유리하게 활용될 수도 있다. 이에 본고에서는 우선 석탄을 중심으로 하는 저급자원 가스화에 의하여 합성가스를 생산하는 가스화 기술을 소개하였다. 이어서 합성가스를 사용하는 주요한 응용분야로서 국내외에 비교적 잘 알려진 석탄가스화 복합발전(IGCC: Integrated Gasification Combined Cycle) 기술의 개념을 요약하였다. 다음으로는 합성 청정에너지인 대체천연가스(SNG: Substitute Natural Gas, Coal to SNG)를 생산하는 기술, 합성석유(Synthetic Crude Oil)를 생산하는 GTL(Gas to Liquid, Natural gas to synthetic crude oil) 기술과 CTL(Coal to Liquid, Coal to synthetic crude oil) 기술 등을 간략하게 정리하였다. 마지막으로는 석탄, 석유코크스, 폐기물, 바이오매스(가연성) 등 저급자원으로부터 수소를 생산하는 개념을 소개하였다. 궁극적으로는 재생에너지로부터 생산되는 전기와 재생에너지의 간헐성에 의하여 발생하는 잉여전기를 이용하여 생산한 수소가 미래의 에너지가 되어야 하며, 먼 미래에는 반드시 그러한 시대에 도달할 것으로 예상할 수 있다. 그러나 재생에너지 기술은 아직도 기술적 측면에서 상대적으로 덜 성숙된 기술이며 경제적인 측면에서도 아직은 REC(Renewable Energy Credit) 등 보조에 의존하여야 한다. 이런 상황을 고려하면 단기/중기적인 관점에서는 화석연료 기반 경제사회에서 재생에너지 전기와 수소를 기반으로 하는 경제사회로 넘어가는 과정에서 저급자원을 활용한 합성가스 생산 및 이를 활용한 청정에너지 생산 기술이 징검다리 역할을 해주어야 할 것으로 판단된다.

석탄자원 이용 독립형 에너지생산 플랜트 개발

라호원, 윤성민, 서명원, 문태영, 문지홍, 윤상준, 박성진, 이재구, 이호태, 정헌
한국에너지기술연구원 청정연료연구실

Development of distributed energy production plant using coal

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석탄을 보다 효율적이고 청정하게 이용할 수 있는 기술로 석탄 가스화를 이용한 전환 공정이 다양한 형태로 개발되고 있다. 가스화 공정을 통해 생산된 합성가스는 CO, H2가 주성분이며, 이러한 합성가스는 전환 공정을 거쳐 전기, 합성석유, 합성 천연가스, 화학원료(Methanol, Ammonia)등 다양한 형태로 변환이 가능한 장점을 가지고 있다.[1] 한국에너지기술연구원에서는 1980년대부터 석탄 가스화 기술에 대한 연구 개발을 시작하였으며, 습식 분류층 가스화기술을 중심으로 연구를 진행하고 있다. 대표적인 성과로 10.0ton/day급 분류층 가스화기의 가압 운전을 통해 합성가스 정제 공정인 Rectisol□공정과 Fisher−Tropsch 공정, 합성가스 발전 엔진과의 연계운전을 통해 Pilot급 합성 석유 생산 플랜트 기술개발을 진행하였다.

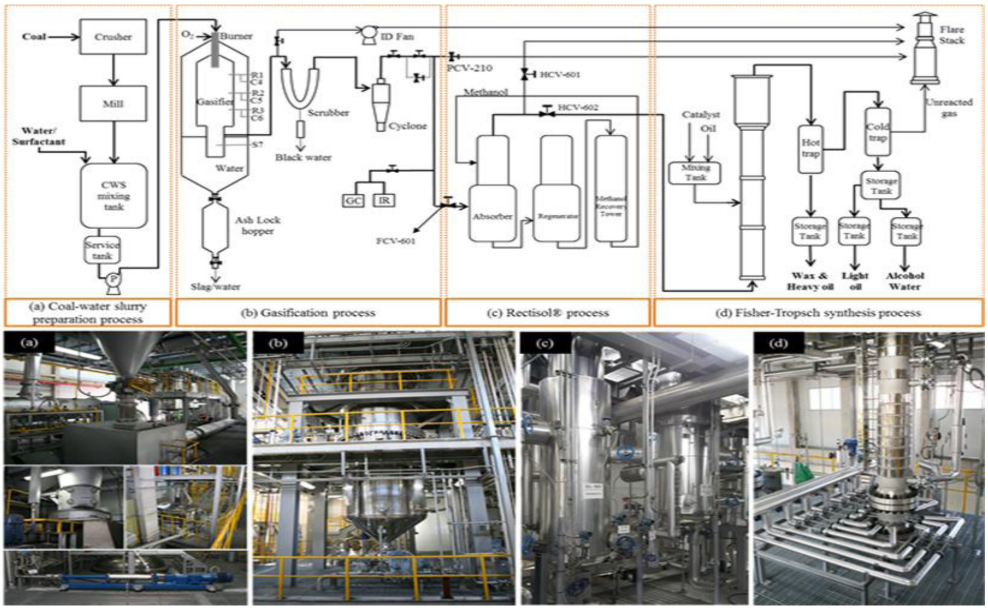

Figure 1. Schematic diagram and photographs depicting the KIER ICTL plant. (a) Coal-water slurry preparation, (b) gasification, (c) Rectisol® and (d) F-T process modules.

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석탄 화력발전소에서 온실가스 감축기술 현황

이 재 구 한국에너지기술연구원 FEP융합연구단

Status of Technology to Reduce Greenhouse Gas in Coal-fired Power Plant

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2050년 탄소중립 실현을 위한 이행계획에 따라 온실가스 감축을 위한 실천 방안들이 점차 구체화 되고 있다. 탄소중립으로 가기 위해서는 에너지절약, 효율향상. 재생에너지, 원자력, 수소이용, CCUS와 관련된 에너지 기술들이 필요하다. 탈탄소를 위한 재생에너지 보급은 확대되어야 하며 간헐성 문제, 낮은 이용율, 국내 잠재량 한계, 발전원가상승 등에 대한 대안마련과 불확실성 해소가 시급히 해결되어야 할 것이다. 석탄 화력발전 분야에서 온실가스 감축을 위해서는 효율향상, fuel switching, CCUS 기술이 적용되어야 한다. 그동안 국내에서는 USC발전, 바이오매스 전소발전, IGCC기술이 개발되어 운전 중에 있으며 CCUS를 위한 CO2 포집기술과 활용 및 저장기술이 개발 중에 있다. 탈탄소를 위한 에너지전환정책에 따라 석탄 화력발전 입지축소는 불가피하나, 에너지 수급 안정성과 온실가스 감축 시나리오에 균형적으로 기여하기 위해서는 발전설비의 효율적인 운영과 신기술 융합을 통한 다양한 기술개발이 이루어져야 할 것이다. 본 발표에서는 CO2 감축과 관련된 청정석탄 화력발전기술 개발현황과 향후 역할 및 방향성에 대하여 살펴보고자 한다.

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폐활성탄이 충진된 활성탄 카트리지의 휘발성 유기화합물 저온 탈착에 관한 연구

강신욱, 이성우, 손두정, 한문조, 이태호, 홍성오 (주)우진이엔지, 숭실대학교 융합연구원

A Study on Low Temperature Desorption of Volatile Organic Carbon of Cylindrical cartridge fill with waste activated carbon

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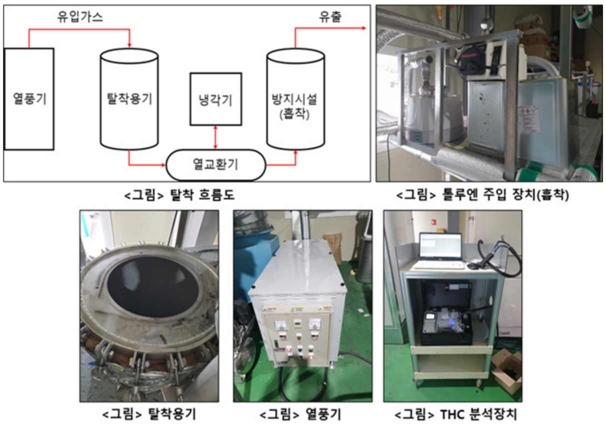
Woo Jin Co.,Ltd, Soongsil Convergence Research Institute

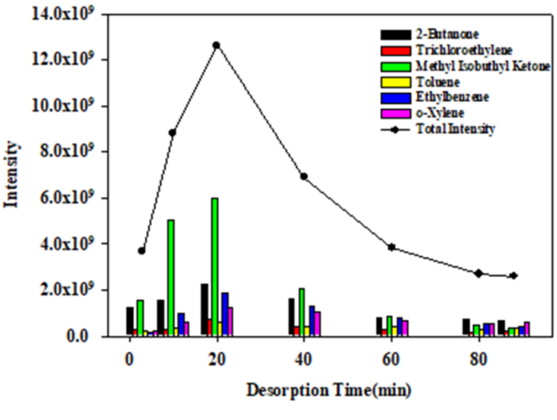
현재 활성탄 흡착탑의 활성탄 교체 방식은 별도의 보관 용기 없이 인력을 이용하여 활성탄을 교체를 하였으나 활성탄의 파쇄 및 분진 발생 등의 문제가 있다. 이에 대한 해결 방법으로 원통형 활성탄 카트리지에 활성탄을 투입함으로써 흡/탈착 효율 증가 및 활성탄 교체등의 유지관리가 용이하게 하는 연구가 진행되었다. 따라서 이러한 원통형 활성탄 카트리지에 대하여 실제 폐활성탄을 투입함으로써 활성탄 카트리지의 탈착시의 특성을 확인하였다. 폐활성탄의 탈착시에 발생되는 유기용제를 연소 에너지로 재사용 가능여부를 확인하기 위해 여러 사업장의 방지시설에서 수집한 폐활성탄에 대하여 탈착 가스 성분 분석을 실시한 결과, 흡착량 및 활성탄의 성능 저하가 확인되었다. 일부 공정에 대해서 저급탄이 납품되는 것으로 추정되는 경우도 있어서 활성탄 카트리지에 폐활성탄을 투입하기 전에 별도의 선별 절차가 필요할 것으로 판단된다.



<그림> 탈착 흐름도 <그림> 톨루엔 주입 장치(흡착)

<그림> 탈착용기 <그림> 열풍기 <그림> THC 분석장치

[활성탄 카트리지 흡/탈착 장치]



[탈착시간에 따른 가스 성분분석]

e구두발표

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청정일반

조촉매(Ba, Zr, Nd)가 담지된 Ce/Cu/γ-Al2O3 \ 촉매를 적용한 폐기물 가스화 합성 가스의 고온 수성가스전이 반응으로부터의 청정 수소 생산

안선용, 노현석 연세대학교

Clean hydrogen production from the high temperature water-gas shift reaction using simulated waste-derived synthesis gas over metal (Ba, Zr, Nd) promoted Ce/Cu/γ-Al2O3 catalyst

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Metal (Ba, Zr, Nd) promoted Ce/Cu/γ-Al2O3 catalysts were investigated for clean hydrogen production from the high temperature water-gas shift reaction using simulated waste-derived synthesis gas. Ce-Ba/Cu/γ-Al2O3, Ce-Zr/Cu/γ-Al2O3, Ce-Nd/Cu/γ-Al2O3 and Ce/Cu/γ-Al2O3 catalysts were prepared by a sequential impregnation method and applied to the water-gas shift reaction using simulated waste-derived synthesis gas at a gas hourly space velocity (GHSV) of 50,060 mL/g·h. The physico-chemical properties of Ce/Cu/γ-Al2O3 catalysts promoted with various metals (Ba, Zr, Nd) were characterized using various analysis techniques such as BET, TPR, XRD and N2O titration. The characterization results for each catalyst were correlate with its catalytic activity in the high temperature water-gas shift reaction using simulated waste-derived synthesis gas.

Anticoagulant and antioxidant activities of sulfated polysaccharides extracted from oyster mushroom (Pleurotus ostreatus)

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In this study, polysaccharides from oyster mushrooms (Pleurotus ostreatus) were extracted using subcritical water extraction (SWE) from 120 °C to 180 °C, 20 minutes, and solid/ratio of 1/20. Polysaccharides attained from selected conditions were chemically modified using CSA–pyridine method to enhance their biological activities. The results showed that SWE at 180 °C recovered the most polysaccharides from the sample. The sulfate content of modified polysaccharides was 16.83% with the degrees of substitution (DS) approximately 1.83. Fourier-transform infrared spectroscopy (FTIR) confirmed the success of the chemical modification with the peaks of sulfite groups seen at the wavelength 796, 1223, 1379 nm. Both polysaccharides were composed of only mannose in thin layer chromatography analysis. Regarding biological activities, sulfated polysaccharides showed surprisingly strong anticoagulant activity by intrinsic blood coagulation pathways as they extended the plasma clotting time for more than 3 times at a concentration of 15.62 μg/mL as compared with the blank. Besides, sulfated polysaccharides exhibited strong scavenging effects against reducing power and hydroxyl free radicals. However, they showed a weaker effect on ABTS+ scavenging activity compared to the native polysaccharide. Native polysaccharides and sulfated polysaccharides showed a low level of cytotoxicity on normal cells, including HaCaT and HEK 293 with IC50 approximately 1463.6, 1401.7 and 1116.5, 603.9 μg/mL, respectively. Therefore, sulfated polysaccharides obtained from oyster mushrooms (P. ostreatus) could be considered as an alternative to anticoagulant therapy.

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Depolymerization of Kraft lignin into valuable fuels in an aqueous medium over ZnO-Co/N-CNTs

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Because of global warming and the depletion of fossil fuels, the use of renewable energy resources to meet current energy demands has received considerable attention. Lignin, which is an abundant and globally distributed natural aromatic polymer, is one of the most promising renewable resources for producing sustainable fuels and value-added chemicals [1]. Catalytic conversion of technical lignin to value-added chemicals and fuels is important for realizing economically viable lignocellulosic biomass refineries. The choice of catalyst and solvent is critical for the effective conversion of the technical lignin to chemicals and fuels by cleavage of the C–C bonds. Catalytic depolymerization and hydrodeoxygenation of Kraft lignin (KL) were investigated over bimetallic ZnO and Co deposited on N-doped carbon nanotubes (ZnO-Co/N-CNTs) in an aqueous medium [2]. Almost complete KL conversion with a high bio-oil yield (52 wt%), a high degree of deoxygenation (DOD, 59.0%), and a high monomeric yield (12.1 wt%) were achieved over ZnO-Co/N-CNTs at 350 °C and 6 h reaction time. At 400 °C, the monomeric yield and DOD increased to 24.4 wt% and 61.0%, respectively. In addition, the produced bio-oil exhibited high-calorific values of 34.3–37.0 MJ kg–1 because of the high activity of ZnO-Co/N-CNTs for hydrodeoxygenation. ZnO-Co/N-CNTs outperformed most of the metal-supported catalysts including 5 wt% Pd, 5 wt% Ru, 5 wt% Pt, 66 wt% Ni, and CoMo on various supports of activated carbon and alumina. The use of water as the solvent resulted in much higher bio-oil and monomeric yields than those using methanol, isopropyl alcohol, and n-hexane. The high bio-oil and monomeric yields with a high DOD in water make ZnO-Co/N-CNTs highly attractive in the development of an environment-friendly technical lignin conversion process.

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초임계유체 기술을 이용한 폐유지 유래 바이오디젤 생산

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Production of biodiesel from waste oil and fats using supercritical fluid technology

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현재 국내 시판 경유에는 바이오디젤이 3% 혼합되어 유통되고 있으며, 올 하반기부터 혼합비율이 3.5%로 상향되고 향후 5%까지 확대될 것으로 전망되고 있다. 이에 따라 바이오디젤의 수요는 지속적으로 증가할 것으로 예상되나, 우리나라는 인구와 산업 규모에 비해 국토 면적이 작아 경작을 통한 원료 수급에는 한계가 있다. 이를 극복하기 위해서는 해외로부터 원료를 수입하거나 국내에서 발생하는 폐유지를 적극 활용하는 방안을 고려할 수 있다. 폐유지는 주로 농축산 부산물, 가정이나 식당에서 배출되는 음폐유 등을 포함하고 있으며 발생원에 따라 구성 성분과 조성이 다양하다. 대부분의 폐유지는 공통적으로 수분 함량과 산가가 높기 때문에 현재 사용되고 있는 알칼리 촉매 공정에 직접 투입할 경우 비누화 등의 문제가 발생할 수 있어 별도의 정제 공정이 필요하다. 폐유지의 산패 정도가 심할수록 이러한 정제공정 비용은 높아지게 되어 제조 단가를 올리는 원인이 되며, 폐유지에 다량의 유무기 불순물이 포함되어 있는 경우 이에 대한 분리공정 비용도 발생하게 된다. 이와 같은 폐유지의 한계를 극복하기 위해 다양한 정제공정이 개발되고 있는 한편, 알칼리공정을 대체하면서 폐유지를 직접 처리 가능한 새로운 제조공정에 대한 개발도 이루어지고 있다. 본 발표에서는 이 중 초임계유체 기술을 이용한 바이오디젤 제조공정 개발 사례에 대하여 정리하였다. 구체적으로는 폐유지의 특성 분석, 초임계메탄올을 반응용매로 이용하여 무촉매 조건에서 바이오디젤을 제조하는 공정 개발, 금속촉매 또는 생촉매공정에 초임계유체를 도입하여 효율을 높인 하이브리드 공정 개발에 관련한 연구결과를 소개하고, 향후 과제에 대해서도 논하고자 한다.

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국내 산업에서의 VOCs 처리 기술 현황 및 비교

김지현, 김진호, 김효식, 류재홍, 강석환 고등기술연구원

Current status and comparison of VOCs treatment technology in the domestic industry

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전 세계적으로 대기환경오염으로 인하여 이상기후가 발생하자 이에 대한 경각심을 갖고 각 오염원(생산공정, 연소공정, 이동오염원 등)으로부터 배출되는 오염물질을 처리하고자 여러 가지 연구를 진행하고 있다. 대기환경오염원 중 본 논문을 통해 다룰 주제는 휘발성 유기화합물에 대한 내용이다. 휘발성 유기화합물(VOCs; Volatile Organic Compounds)은 광화학스모그의 원인 및 발암성 물질로서 인체에 매우 유해하며, 악취의 원인이 되기 때문에 이에 대한 규제치가 강화되고 있다. 특히 VOCs는 발생하는 공정에 따라 조성이 달라 그에 맞는 처리 기술이 적용되는 것이 중요하다. 그렇기 때문에 배출되는 VOCs를 처리하기 위해 다양한 기술이 산업화되어 있지만 각 기술들의 단점들을 보완하고 더 효율적으로 VOCs를 저감하기 위하여 지속적으로 연구가 진행되고 있는 상황이다. 이에 따라 본 연구에서는 변화하고 있는 대기환경오염물질에 대한 정책을 살펴보면서 국내 산업 시설에서 배출되는 VOCs의 조성을 비교함으로써 그에 적합한 처리 기술들을 제시하였다. 제시한 기술들에 대해 장단점을 비교함으로써 앞으로 필요한 기술 방향성에 대해 정리하였다.

본 논문은 환경부 미세먼지 사각지대 해소 저감사업의 지원에 의하여 연구되었으며 이에 감사드립니다. (과제번호:202003060012).

Hydrogenolysis of alginic acid over mono and bimetallic ruthenium/nickel supported on activated carbon catalysts with basic promoters

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Biorefinery, in which renewable resources are utilized on a large scale, is a potential alternative based on biomass feedstocks. [1] Algal biomass, also known as the third-generation biomass, is inedible, lignin-free, and shows rapid growth, and has significant advantages in biorefinery. [2] As the main component of macroalge, alginic acid is a good carbon source for the production of various value-added chemicals such as acids and alcohols. Hydrogenolysis of alginic acid over Ru, Ni and Ru-Ni supported on activated carbon catalysts was performed in a batch reactor using NaOH, CaCO3, Ca(OH)2, and Mg(OH)2 as basic promoters. Among the promoters used, NaOH provides the highest carbon efficiency and yield of glycols, such as ethylene glycol and 1,2-propanediol. In addition, various organic acids such as lactic acid, glycolic acid, and formic acid were produced in the form of salts. The hydrogenolysis of potential intermediates such as sorbitol, mannitol, lactic acid, and glycolic acid demonstrated direct conversion of alginic acid to glycols without sugar alcohols or organic acids as reaction intermediates. Furthermore, Ru-Ni bimetallic catalysts as a function of the Ni/Ru molar ratio were used to increase the yield and selectivity to glycols. The highest yield of glycols, 24.1%, was obtained when the Ni/Ru molar ratio was 1:1, due to the enhanced interaction between Ru and Ni based on H2-TPR.

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소각시설 복합오염물질 처리용 PTFE membrane 여과필터 제조 및 운전 특성

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Fabrication and Operation Characteristics of PTFE membrane Bag-filter for Simultaneous Removal of Combined Pollution

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미세먼지는 복합 성분을 가진 대기 중 부유물질로서 화석연료 연소, 자동차 배기가스, 산업용 제조 공정 등에서 발생하게 되는데 최근 화력발전소 및 연소시설 등에서 배출되는 미세먼지가 사회적 이슈가 되고 있다. 특히, 산업시설 연소과정에서 발생되는 미세먼지는 1차오염원에서 대기 중으로 직접 배출되거나 미세먼지의 원인물질인 연소생성물이 전구물질로 작용하여 화학반응을 통해 2차적으로 생성되어 대기 중으로 배출되고 있으므로 복합오염물질 배출억제 노력과 체계적인 환경관리의 필요성이 증가하고 있다. 이로 인해 최근 복합오염물질 제거를 위한 고효율 필터미디어 제조 및 시스템 개발이 진행되고 있으나 개발 실적이 미흡하고 고가의 원자재를 해외에서 수입하여 사용하고 있는 실정이다. 이에, 본 연구에서는 소각시설 복합오염물 동시 처리를 위한 촉매코팅 여과필터를 국산화 개발하고자 250℃ 고온 조건에서 사용가능하고 내산성 등 내화학성이 우수한 고강도 지지체용 PTFE fiber 부직포 및 여과미디어를 이용하여 PTFE membrane 여과필터를 제조하였고 pilot급 시험용 집진장치를 이용하여 분진부하 조건에서 차압, 여과 특성 등 필터의 기본적인 운전 특성을 파악하였다.

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Microfluidic preparation of highly monodisperse organic-inorganic hybrid particles

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This study presents a microfluidic method for preparation of organic−inorganic hybrid microspheres with poly(Dodecanediolo Dimethacrylate-co-Trimethoxysillyl propyl methacrylate) (P(DDMA-co-TPM)) as the core and silica nanoparticles as the shell. In this process, the monodisperse microspheres of P(DDMA-co-TPM) were first synthesized via microfluidic approach of droplet generation combined with in situ photopolymerization, and nanosilica particles gradually grew on the surface of microsphere via hydrolysis and condensation of tetraethoxysilane (TEOS) in basic ammonium hydroxide medium without additional surface treatment. The morphology, composition, and crystalline structure of the hybrid microspheres were confirmed by scanning electron microscopy, transmission electron microscopy, Fourier transform infrared spectroscopy, EDS, and XPS analysis, respectively. The results indicated that the shell of the complex microspheres consists of SiO2 microspheres with about 60 nm. Finally, we suggest the coating mechanism of SiO2 nanoparticles on the polymeric microsphere.

Effective mine dust monitoring and assessment using a low cost sensor network

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The airborne dusts emitted from open pit mine or quarry sites can be dispersed into the neighboring regions and deteriorate the air quality of the vicinity. The dust dispersion and its resultant environmental impacts should be properly monitored and assessed, respectively. However, such tasks for mine dust dispersion requires installation of a proper dust monitoring network with multiple sensors, prediction by mathematical modeling, and relevant big data processing, which should often be cost and time consuming tasks and thereby needs an effective strategy. Therefore, this study proposed a strategic systemized approach to facilitate the mine dust monitoring and the impact assessment. This approach includes (1) deployment of low cost dust sensors and establishment of the remote sensor network (2) application of dispersion modeling to predict dust dispersion from emission sources to receptors located far from the monitoring sites (3) application of big data processing to enhance the monitoring and the modeling data quality.

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CO2-assisted depolymerization of biomass to fuels and chemicals

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Depolymerization of lignocellulosic biomass such as cellulose and lignin oftentimes involve the use of harsh reaction conditions such as high acid concentration and elevated temperature. Especially, mineral acids such as HCl are commonly employed to effectively attack the solid biomass structure which is not soluble in water solvent. However, the use of mineral acid in biomass processing is not desirable due to separation and process safety issues. Herein, we present the novel technology for mild-condition biomass depolymerization using CO2 as an acid catalyst. The CO2 dissolved in water reacts rapidly to form carbonic acid and this, in turn, partially dissociate to form hydrogen and bicarbonate, resulting in an acidic solution. By adding CO2 to the reactor system up to 150 bar, the pH of water can reach ~3.0 at 150°C, which is sufficient to have catalytic effect on biomass hydrolysis. We will discuss how this high-pressure CO2-induced acidity assists the biomass depolymerization efficiency when combined with the heterogeneous catalyst for two cases: 1) hydrolysis of cellulose to glucose over sulfonated activated carbon catalysts and 2) hydrogenolytic depolymerization of lignin to phenolic monomers over supported ruthenium catalysts.

Metallic monolith catalysts for selective catalytic reduction of NOx with NH3 from industrial exhaust gases

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To reduce the environmental pollution by NOx, selective catalytic reduction (SCR) process is the most commercial De-NOx system in order to meet the requirement of emission regulation from industrial facilities such as steelworks, power plants, industrial boilers, cement kilns and turbines. In generally, commercial ceramic honeycomb catalyst (CHC) has been installed in SCR system. However, the CHC has some serious problems such as low strength and easy destruction at various sources of exhaust gas. For these defects, metallic structured catalyst (MSC) was applied to the SCR system. The MSC are made of thin metal foils, flat and corrugated, formed into a honeycomb structure which is placed inside a metal shell. The advantages of metal substrates are their high geometric surface area and low pressure drop associated with the thin walls. In our study, the MSC for SCR was prepared using the SUS-based substrate by slurry wash coating method. The coating slurry with inorganic and organic binders was controlled by pH and viscosity. The MSC was fabricated with strong adhesion by coating, drying, and calcination process. The MSC was carried out the SCR performance and durability test compared to the commercial honeycomb catalyst. The metallic catalyst substrates could be a good alternative as a new type of SCR catalyst for marine engine and steelworks.

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Acknowledgments

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청정융합

Albumin Nanoparticle as a Promising Carrier for Bilirubin

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Albumin is the most abundant protein in blood with a long circulatory half-life and a capability to bind various nutrients, metabolites, and metals, lending itself to a promising vehicle for drug delivery as well as adsorption. Of note, transformation of albumin into a nanoparticle greatly improves the capacity to occupy payloads and tolerate harsh conditions, thus expanding its utility and compatibility. Here, we investigate a potential application of albumin nanoparticle as a carrier encapsulating bilirubin for cancer treatment. Bilirubin is a natural by-product of the hemoglobin catabolism and serve as an endogenous antioxidant that eliminates reactive oxygen species (ROS). Oxidative stresses by reactive oxygen species (ROS) are known to activate many cancer-promoting molecules, such as Ras, PI3K/Akt, ERK1/2, p38 MAPK, and JNK1/2. Accordingly, bilirubin is deemed an effective anti-cancer agent as well as ROS scavenger. However, its low water-solubility and high sensitivity to oxygen restricts further clinical developments, requiring an appropriate drug carrier. We show that albumin nanoparticles could encapsulate bilirubin with a stable size around 120 nm, and a spherical morphology. The entrapment efficiency (EE) was around 60%, and the drug loading (DL) was around 10%.

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Energy-saving pretreatment and fermentation of microalgal strains to improve biofuels production

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Microalgae have been considered as one of the most promising feedstock for biofuels (bioethanol, higher alcohols (C2-C5), and biodiesel) production that can replace fossil fuels. The energy recovery from microalgal is significantly influenced by their physiological properties such as cell wall thickness and proportions of biocomponents. We developed a novel integrated approach to achieve unprecedented biomass utilization (80-93%), conversion efficiency (46-48%) from Pseudochlorella sp., Chlamydomonas mexicana, Chlamydomonas pitschmannii via microwave pretreatment (at 210 W, 2 min), successive fermentations, and transesterification. Scanning electron microscopy visualized significant disruption of microalgal cells. Carbohydrate fermentation by Saccharomyces cerevisiae YPH499 produced 0.45-0.47 g/g bioethanol yield and fermentation of the leftover microalgal proteins after carbohydrate fermentation by S. cerevisiae S288C produced 0.44-0.45 g/g higher alcohols yield. Fermentations served as a bio-pretreatment to enhance the bioavailability of intracellular compounds, which minimized the use of expensive and laborious methods for their extraction from the microalgal biomass. The transesterification of the remaining lipid portion produced 0.62-0.74 g/g biodiesel. Microwave pretreatment saving ca. 32 times specific energy than ultrasonic pretreatment. This study provides a proof-of-concept that it can encourage the use of microalgal biomass for cost-effective biofuels production in a large-scale process.

Keywords

Microalgae biofuels, Biomass pretreatment, Biomass utilization, Conversion efficiency, Specific energy

Biodegradation of emerging contaminants (sulfamethoxazole, sulfamethazine, and doxylamine) using Iris pseudacorus and periphytic biofilm

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Emerging contaminants (ECs) are affecting the environment and living beings even in trace amounts present in waterbodies [1]. Bioremediation offers an alternative to conventional tertiary treatment of wastewater through efficient removal of ECs in cost effective manner [2,3]. Iris pseudacorus and the attached periphyton for synergistic biodegradation of three frequently found ECs was assessed in the current study. I. pseudacorus showed removal values of 100%, 83%, and 78% for sulfamethoxazole (SMX), sulfamethazine (SMZ), and doxylamine (DOX), respectively, at the concentration of 0.05 mg $L^{-}1$, and the respective values at the higher concentration were 50%, 42%, and 59%, in 10 days. The mass balance according to individual studies showed that the major removal mechanism for SMX and SMZ was biodegradation, while it was bioadsorption for DOX. Furthermore, plants followed first-order kinetics for the removal of SMX and SMZ, while pseudo-first order (0-1 day) and first order (1-10 days) kinetics were followed for DOX. The removal rate of SMX increased by 26% on the first day with I. pseudacorus and a periphytic biofilm consortium, compared with the values corresponding to their individual performances. The identified metabolites of SMX were less toxic than the parent compound. A phytoreactor (30 L) planted with I. pseudacorus and the periphytic biofilm consortium facilitated improved removal of these ECs and reduction of organic/inorganic compounds in secondary wastewater effluent. Thus, evaluating the synergistic effects of periphytic biofilm with I. pseudacorus helped in understanding the degradation mechanism of naturally formed consortium, which could be exploited for wastewater treatment.

Keywords

Phytoremediation; Iris pseudacorus; Sulfamethoxazole; Sulfamethazine; Doxylamine; Toxicity.

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Improved anaerobic digestion of lignocellulosic components of rice straw fractionated by combined hydrothermal and deep-eutectic solvent pretreatment

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Lignocellulosic (LC) biomass is an abundant feedstock that can be converted into biomethane during anaerobic digestion (AD). However, maximizing the bioavailability and conversion of LC-biomass during anaerobic digestion is a key challenge because of recalcitrance and poor degradability of this biomass. In this study a combined hydrothermal and deep eutectic solvent (DES) pretreatment strategy was employed to effectively fractionate lignocellulosic components of rice straw i.e., hemicellulose, cellulose, and lignin for their efficient conversion in AD for high-rate methane production. The hydrothermal pretreatment of rice straw was optimized using a 3-factor, 3-level Box-Behnken design to determine the optimum temperature, concentration of H2SO4, and pretreatment time. The optimization resulted in a maximum soluble sugar release of 166 mg g−1 in the hydrolysate when the biomass was soaked in 0.6% v/v H2SO4 overnight and hydrothermally treated at 150 °C for 90 min. Analysis by scanning electron microscopy, X-ray diffraction (XRD), and Fourier transform infrared spectroscopy revealed that combined pretreatment promoted extensive disintegration and fractionation of the lignocellulosic components of rice straw. The XRD analysis indicated 76% increase in crystallinity index of pretreated biomass compared to that of the untreated control. Mesophilic AD of pretreated biomass resulted in a significant boost of methane yield (406.59 mL g−1) which is 57% higher than that with untreated biomass. While thermophilic AD of pretreated biomass resulted in 38% increased methane yield (326.46 mL g−1) compared to that of untreated biomass. Combined hydrothermal and DES pretreatment has demonstrated to be an efficient technique for enhancing the digestibility of LC-biomass such as rice straw in mesophilic and thermophilic AD, accompanied by enhanced substrate utilization and methane yield.

Keywords

Lignocellulosic biomass; Pretreatment; Anaerobic digestion; Biomethane; Rice straw.

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Metagenomic analysis of anaerobic co-digestion revealed enhanced carbohydrate and lipid metabolism in food waste and sewage sludge reactor

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Methanogenesis, a complex biological process influenced by numerous intrinsic and extrinsic factors, can be optimized and full-scale applied through understanding the interrelation between the degradation mechanism and microbial community composition, along with an in-depth analysis of metabolic pathways [1-3]. In anaerobic co-digestion, to determine the optimum FW concentration along with wastewater treatment sludge and reactor conditions, this study was carried. The effect of higher substrate loading on microbial abundance and the methanogenic community was studied. Higher methane production and short lag phase were observed in the lower FW reactor group (<4%) while extended the lag phase and incomplete substrate utilization observed in the higher FW reactor group (>6%). Low FW concentration increased methane production by 5.2 to 8.1-fold. The optimum FW concentration was 4% as the highest methane production (8.1-fold) with a short lag phase of 5 days observed. The Long-chain fatty acids (LCFAs) degradation was directly dependent upon initial FW loading concentrations, and up to 99% LCFA degradation occurs at 4% FW reactor. The addition of either 8 or 10% FW inhibited methanogenesis due to the accumulation of VFA and low LCFA reduction. Under optimum biomethane production (4% FW), Methanosaeta and Methanosarcina were abundant, indicating their role in methanogenic and syntrophic acetogenesis, along with enhanced metabolic pathways specific for carbohydrate and lipid metabolism. The addition of 2% FW in AD increased the methane yield 4-fold, without a lag phase. The current study recommends running reactors at 4% (v/v) FW loading to attain the maximum substrate utilization and methanogenesis.

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Syntrophically associated microbiota induced methanation in anaerobic digestion of various organic waste

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Globalization creates rapid increment in industrialization to meet the societal needs. One of the biggest areas of growth is the agro-food industries, which generate and discard enormous amounts of organic waste such as fruit and vegetable processing wastes (polysaccharidic waste) and animal by-products (lipidic waste) into the environment [1, 2]. Biomethanation through anaerobic digestion (AD) is the most reliable energy harvesting process to achieve waste-to-energy following augmentation with various organic waste due to their high organic content and theoretical conversion efficiency, compared to sewage sludge (40–50%) alone [3, 4]. Our investigation revealed the improved digester performance depends on its microbial syntrophy during the AD and the substrate type. A positive association between propionate-oxidizing acetogens (i.e., Anaerolinea, Bellilinea, Levilinea, and Longilinea) and acetoclastic methanogens such as Methanosaeta and Methanosarcina in the AD of polysaccharidic waste accelerated the methanogenic activity by seven times in the digesters. In contrast, syntrophic interactions among acetogenic long chain fatty acid oxidizers Syntrophomonas and acetate-oxidizing Clostridium with Methanosarcina improved the methanogenic activity 63% of the lowest lipidic waste loading. Thus, alteration in the digester feeding with heterogenic organic waste causes diversification in the digester microbiota and impacts the intricate interspecies networks and their performance for improved methanation.

Keywords

Syntrophy, Anaerobic digestion, Organic waste, Acetoclastic methanogens, Methane.

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시화/안산 스마트허브내 금속가공/화학업종 미세먼지 발생현황 및 방지시설 유효성 특성

이태호, 양한규, 유승열, 오혁진, 최여진
숭실대학교 화학공학과, 시흥녹색환경지원센터

Characteristics of the emission of the fine dust and the effectiveness of prevention facilities in the metal processing/chemical industry of Sihwa/Ansan smart-hub

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Soongsil University, SiHeung Green Environmental Center

시화/안산 스마트허브(집중 산업단지)의 경우 다양한 업종의 많은 수의 공장들이 현재 조업중이다. 이들 중 금속/화학/섬유 업종등이 미세먼지 발생이 가장 많은 것으로 알려진 업종이다. 본 연구에서는 금속가공/화학업종의 미세먼지 발생현황을 조사하고 그 미세먼지의 물리화학적 특성 및 배출 현황을 현장 조사와 분석, 시료 분석을 통해 알아보고 각 업체에 설치된 방지시설의 제거효율을 통해 방지시설 효율성을 평가하였다.

그 결과 방지시설 후단(배출부)에서의 미세먼지 측정결과는 관련 기준인 30㎎/S㎥을 하회하는 범위인 0.3 ㎎/S㎥ 에서 18.7㎎/S㎥ 으로 측정되었다. 미세먼지 제거효율은 약 4.3% 부터 97.3%까지로 계산되었다. 여과집진방식이 세정방식보다 더 높은 제거효율을 보이고 있음을 확인할 수 있었다.

중금속성분 분석에서는, 금속가공 업종에서 주로 아연, 니켈, 철 성분이 1 ~ 15% 정도의 함유량으로 각 업체별/가공방식별로 함유량의 차이가 크게 발생하였다. 전체적인 중금속 배출량은 적으나 몇몇 업체의 경우 일 배출량이 적지 않으므로 향후 이들 업종에 대한 중금속 배출정도에 대한 부분은 관찰할 필요가 있을 것으로 사료된다. 제거효율 측정에 의한 방지시설의 유효성을 판단하는데 있어서는 현재의 방지시설은 유효성에 큰 문제가 없는 것으로 판단되나 세정방식보다는 여과집진이 더 효율이 높은 것으로 판단된다.

결론적으로 금속도금, 금속가공 및 화학 업종에서의 미세먼지의 발생특성 및 방지시설의 효율 분석을 수행한 결과 각 업종별로 미세먼지 발생현황, 입자별 분포현황, 미세먼지 제거특성, 미세먼지 내의 중금속 특성 및 성분 등을 살펴볼 수 있었다. 이러한 접근 방법을 다른 미세먼지 발생 업종에 적용하면 업종별로 특성화하여 그 경향을 파악하고 대책을 마련하는데 도움이 될 수 있으리라 판단된다.

본 연구는 시흥녹색환경 지원센터의 연구과제 지원에 의해 수행되었습니다.

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청정공정

Sustainability Comparison of Domestic Production of Green Hydrogen and Hydrogen Produced from Imported Green Ammonia

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Moving to the hydrogen economy entails challenging decisions from economic processes to environmental environment and social acceptance. Hydrogen must be derived from renewable energy and abundant energy in cost-effective, environmentally, and socially sound ways to ensure sustainability. The cost barrier in the domestic production of hydrogen from renewable energy sources such as solar and wind is creating a room to import clean energy to produce cost effective and environment friendly hydrogen. Government of the Republic of Korea unveiled the ‘The Roadmap of Hydrogen Economy’ in earlier 2019. This roadmap appeals the investors and technologists to think out of the box for the hydrogen energy and to meet the hydrogen challenge countries like Japan and South Korea are thinking to import hydrogen from low-emission processes. The plan of importing green NH3 from Australia and generate H2 after thermal cracking, needs an intensive analysis on the basis of environment and economic sustainability. This research will result an in-depth sustainability comparison of both cases and provide input in decision-making processes at both industry and hydrogen technology policy-makers level.

전이금속/제올라이트 촉매 상에서 반응온도와 공간속도가 polycyclic aromatic hydrocarbons 의 수첨분해반응에 미치는 영향

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Effect of reaction temperature and space velocity on the hydrocracking of polycyclic aromatic hydrocarbons on transition metal/zeolite catalysts

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Polycyclic aromatic hydrocarbons (PAHs)는 나프탈렌, 나프탈렌 유도체 및 페난트렌 등과 같은 2-ring aromatic hydrocarbons 및 3-ring aromatic hydrocarbons로 구성되어 있다[1-3]. 현재 대부분의 PAHs는 점도 조정제 또는 공정 연료로 쓰이고 있다[4]. 그러나 PAHs는 불순물이 적으며 높은 방향족함량을 갖고 있어 benzene, toluene 및 xylene와 열안정성 연료의 원천으로 여겨지고 있다[1,3,4]. 본 연구에서는 PAHs로부터 열안정성 연료의 주성분을 제조하고자 하였다. 이를 위해 dual-functional catalyst로서 전이금속을 제올라이트 지지체에 담지한 촉매를 제조하였다. 제조한 촉매의 화학적 및 물리적 특성은 N_2-adsorption, X-ray diffraction, NH_3-temperature programmed desorption 그리고 H_2-temperature programmed reduction을 이용하여 분석하였다. 이후 전이금속/제올라이트 촉매 이용하여 trickle-bed reactor에서 반응온도와 공간속도가 PAHs의 수첨분해반응에 미치는 영향을 고찰하였다.

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High-throughput, Multiscale Computational Evaluation of Metal-organic Frameworks for Energy-efficient SF6/N2 Separation

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We combined high-throughput molecular simulation with process-level simulation to computationally screen CoRE MOF database 2019[1] with the aim of high-performing materials for SF6/N2 separation. The top 3 materials are finally selected as the promising adsorbents based on the energy consumption evaluation in each VSA and PSA cases. For the PSA simulation, ideal PSA cascade simulation is suggested to boost the SF6 maximum purity. The relations between the structural properties of MOF, the adsorption isotherm shapes of the top materials, and the adsorption process performance is analyzed looking at the top 10 screened adsorbents.

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Renewable Energy System for Hydrogen Production Via Alkaline Water Electrolysis with Battery Energy Storage System

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The continuous expansion of renewable energy demands a need for control and storage strategies to ensure stable and reliable energy supply. Small amounts of energy storage can be efficiently stored in batteries and supercapacitors, whereas for long term storage, chemical component such as hydrogen is considered as a suitable candidate. Among various hydrogen production routes, alkaline electrolysis is the most mature and industrially widespread water electrolysis technology for green hydrogen production [1]. Therefore, in this study, a dynamic modeling approach for renewable hydrogen production via alkaline water electrolyzer (AWE) is employed to overcome the fluctuating nature of renewable energy using operational control [2]. The model consists of a solar energy supply coupled with AWE and an energy storage system (ESS). ESS helps meeting the energy instabilities by providing partially stored energy during daytime in batteries, at times of no energy availability (i.e., night) or energy fluctuations (i.e., due to weather conditions) to the AWE avoiding frequent startups and shutdowns, hence providing a continuous green hydrogen production system.

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바이오 순산소 순환유동층 연소 간접 열교환식 초임계 이산화탄소 사이클의 운전특성 분석

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Analysis of operation characteristics of Bio-oxy CFBC with indirect S-CO2 cycle

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전 세계 많은 국가에서 기후변화와 환경 오염 문제를 해결하기 위해 폐기물 자원을 사용하는 재생 에너지 기술에 많은 노력을 기울이고 있다. 목재 폐기물 (WW), 폐지(WP), 젖소 분뇨 (CM)과 같은 생물 폐기물은 재생 에너지의 필수 원천으로 인식되고 있으며, 그 중요성은 시간이 지남에 따라 크게 증가했다. 그러나 바이오 폐기물을 이용한 고효율 발전 공정에 대한 연구는 미흡하다. 바이오 순산소 순환유동층 연소 간접 열교환식 초임계 이산화탄소 사이클은 방출된 탄소를 쉽게 포집하고 이를 재사용하여 높은 효율의 전력을 생성할 수 있는 기술이다. 본 연구에 이용된 공정은 공기분리기, 순산소 순환유동층 보일러 라인, 초임계 이산화탄소 사이클, 이산화탄소 압축 및 정화장치로 구성되어 있으며, 전산모사 프로그램인 Aspen Plus를 이용하여, 20MW급 상용규모로 시뮬레이션 작업을 진행하였다. 국내에서 발생되는 생물 폐기물인 WW, WP, CM을 원료로 이용하였으며, 바이오 매스 성분의 높은 휘발성에도 불구하고 각각 38.4, 37.8, 38.2%의 순 효율을 달성했다. 공기 분리기와 이산화탄소 압축 및 정화장치의 높은 소모 동력이 발생하였으나, 초임계 이산화탄소의 높은 효율로 인해 에너지 페널티를 최소화할 수 있었다.

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A large area analysis method in particle phase according to the incineration of the agricultural plastic film waste

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Air quality problems caused by fine dust are difficult to respond systematically in agriculture, which has limited activity data compared to other industries. There is open-air incineration as a representative cause of the major impact of fine dust in rural areas. In particular, non-collected agricultural plastic film waste can contaminate soil organic matter and adversely affect agricultural productivity (Steinmetz, 2016), and incineration of agricultural plastic film waste generates a large amount of dioxin (2,228pg/kg), reporting the possibility of deteriorating farmers' health (Kim, 2008). To this end, the main types and samples of agricultural plastic film waste missing from the existing open-air incineration study are taken, and the element characteristics of particulate pollutants in agricultural agricultural plastic film waste are identified by linking them with normalized activity data. Previously, to know the elemental characteristics of pollutants, only a portion of the pollutants could be measured with a regular electron microscope, and it was difficult to accurately measure pollutants because additional sample preprocessing was included for observation. To compensate for this, electronic microscopes that can preserve sample samples and analyze them face-to-face have recently been developed to identify the elemental characteristics of all pollutants as a new analysis method of pesticide vinyl sample analysis. In order to monitor the incineration of agricultural plastic film waste, micro-particle analysis technology was applied. This allows the systematic classification of the number, size, and composition of particles for the entire filtered area. Therefore, based on this, we would like to introduce the characteristics of pollutants in particulate matter according to the incineration of vinyl greenhouse waste and confirm the importance of management of agricultural plastic film waste.

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Pilot 규모 순산소 순환유동층에서의 무연탄 연소 시뮬레이션

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Anthracite combustion simulation in a Pilot scale oxy-CFB

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세계적으로 전력의 중요성이 커짐과 동시에 기후변화와 직결되는 온실가스(GHG) 배출을 완화시키는 기술을 필요로 하고 있다. 그 중 순산소 순환유동층 보일러(oxy−CFB)는 연소 전에 질소를 분리하여 동력원으로 순수한 산소만을 이용한다. 낮은 온도에서 연소가 진행되기 때문에 열적 질소산화물(thermal NOx) 생성이 적고, 로내 탈황이 가능하여 오염물질 배출을 줄일 수 있다. 또한 연료의 높은 범용성과 연소로 내의 긴 체류시간으로 인해 저급 연료의 활용까지도 가능하다. 따라서 에너지 자원이 부족한 우리나라는 풍부하고 저렴한 에너지원인 저급탄을 활용해 경제적으로 온실가스 감축에 기여할 수 있다. 무연탄의 상대적으로 낮은 반응성과 복잡한 공정으로 인해 다양한 운전 변수에 따라 급격하게 수력학적 특성이 변하는 순환유동층 내에서 동적 거동에 대한 해석은 필수적이다. 따라서 본 연구에서는 Pilot 규모의 순산소 순환유동층에서 무연탄을 이용하여 세부적인 연소 특성에 대해 CPFD 방법에 기반한 Barracuda®의 상용 소프트웨어를 사용하여 전산해석하였다.

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염료 흡착을 위한 폐커피가루 유래 활성탄소 흡착제의 제조

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Synthesis of Activated Carbon Adsorbents derived from Waste Coffee Powder for Dye Adsorption.

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산업화의 발달과 함께 수질 오염이 심해지면서 수생태계에 악영향을 미치고 있다. 따라서 수질오염의 원인이 되는 물질들의 제거가 반드시 필요한 실정이다. 수질오염 물질을 제거하는 기술에는 흡수, 흡착, 막분리, 전기산화, 촉매산화 등이 있는데, 그 중 흡착은 공정이 간단하고, 운영비용이 적게 소요되어 높은 경제성을 가진다는 장점으로 범용적으로 사용된다. 많은 선행 연구에서 흡착제로 활성탄소, 제올라이트, MOF 등 여러 종류의 흡착제들이 제안 되고 있는데, 그 중 활성탄소는 유기물의 탄화과정과 활성화 과정을 통해 제조되며, 넓은 비표면적으로 높은 오염물질 흡착 성능을 보이고 값이 저렴하다는 장점을 가지고 있다.

국내 커피 산업 규모가 성장함에 따라 커피 원두의 사용규모도 꾸준히 증가하고, 많은 양의 폐커피가루가 버려지고 있다. 폐커피가루를 재사용 하게 될 경우 처리 비용을 감소 할 수 있으며, 추가적인 경제적 이익을 창출 할 수 있다. 본 연구에서는 버려지는 폐커피가루를 이용하여 활성탄소를 제조하고 흡착 공정에 응용하였다. 폐커피가루 유래 활성탄소를 이용하여 수생태계 오염물 제거 모델 반응으로 유기 염료 흡착실험을 진행하였으며, 제조된 활성 탄소는 우수한 흡착성능을 가지는 것을 확인 하였다.

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Fabrication and optimization of methoxy-nonafluorobutane microcapsules for fire suppression

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The damages by electrical fire have been dramatically increased in recent years. The initial installation cost of automatic fire extinguishing systems is high and there is a concern of malfunction which causes greater damage. It is well known that the microencapsulation of liquid fire extinguisher agent is one of the good strategies for preventing a fire without manual operation. The microencapsulation through complex coacervation is considered as one of the most suitable processes for the microencapsulation of highly volatile liquid materials due to their low vaporization temperature and relatively high permeability which can reduce losses of core materials. In this study, we report a simple synthetic strategy for encapsulating the highly volatile eco-friendly liquid agent, methoxy-nonafluorobutane, which have fire suppressing properties through complex coacervation. Furthermore, we incorporated inorganic materials in polymer shell matrix for enhancing both long-term stability and fire extinguishing performance, since inorganic materials generally have higher thermal conductivity and mechanical strength. Characterizations results allow us to identify the effect of inorganic solid species in polymer matrix on fire suppression performance.

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Process optimization of blue ammonia synthesis including carbon capture and storage at low temperature/low pressure

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Currently, ammonia is produced through the Harbor-Bosch process developed in the early 1900s. This process is conducted at a high temperature/high pressure of 350°C or higher and 250 to 300 bar or higher, which consumes a lot of energy and emits large amounts of greenhouse gases. To solve this problem, development of a technology capable of producing ammonia at low/low pressure using hydrogen is in progress. In this study, the blue ammonia synthesis process using the general Haber-Bosch method and the low temperature/low pressure synthesis process were conducted comparative analysis. The comparison factors are energy efficiency, operating cost, and equipment cost.

Finally, the process was optimized to have a production capacity of 20kg/day.

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Steam reforming of methane over porosity controlled spherical nickel catalyst

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As great interests on hydrogen energy increases, hydrogen production technologies are extensively being studied. Among the various methods for producing hydrogen, it is well known that hydrogen production through steam reforming is the most economical way. Since methane has the highest H/C ratio among several hydrocarbons, steam reforming of methane is considered as the efficient strategy for the mass production of hydrogen. In the industrial catalytic process, the catalyst is pelletized into a shaped one with several mm in size to solve the pressure drop problem. However, the reaction rate is faster than the intraparticle mass transfer rate in the steam reforming conditions, resulting that the active metals in the bulk catalyst are not sufficiently utilized. In this study, the pore characteristics of the spherical Al2O3 support with several mm in size were finely adjusted through acid treatment. Active Ni metal nanoparticles are supported on the spherical Al2O3 by wet impregnation followed by calcination. The physicochemical characteristics of the catalysts are studied by XRD, N2 physisorption, H2-TPR, and TGA analysis. We systemically investigate the relationship between the controlled pore property and catalytic performance in the steam reforming of methane reaction.

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Characteristics of Sr0.92Y0.08Ti1-xVxO3-δ (x = 0.01, 0.04, 0.07, 0.12) anode for using H2S fuel in solid oxide fuel cells

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Sr0.92Y0.08Ti1-xVxO3-δ (SYTV) with perovskite structure was investigated as an alternative anode to utilize hydrocarbon fuels in solid oxide fuel cells. To improve the electrochemical performance of Sr0.92Y0.08TiO3-δ (SYT), titanium was substituted with vanadium at the B-site of Perovskite. The SYTV synthesized through the Peccini method was chemically compatible with the YSZ electrolyte without the formation of additional by-products under operating temperature conditions. As increasing substitution amounts of vanadium, the oxygen vacancy increased. V doping in SYT reduced the energy from which oxygen vacancies formed. Ionic conductivity increased due to the oxygen vacancies generated in this way. In addition, resistance to sulfur poisons of several hundred ppm or more contained in hydrocarbons was also increased. The battery performance is 19.30 mW/cm^2 for a 1% substituted battery and 34.87 mW/cm^2 for a 7% substituted battery depending on the degree of substitution of vanadium in H_2 at 850 °C. The cell performance using H2 fuel containing 1000 ppm of H2S at 800°C was 23.37 mW/cm^2 in a battery substituted with 1% vanadium and 73.11 mW/cm^2 in a battery substituted with 7% vanadium. Accordingly, the possibility of SYTV as an alternative anode was confirmed.

Effect of Tin Dopant on Titanium Dioxide Supported Platinum-Tin Bimetallic Catalyst For Low Temperature CO oxidation.

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Removal of carbon monoxide (CO) is a significant issue in the fuel processing which is the most popular strategy for hydrogen production. Bimetallic platinum-tin catalysts are well-known as efficient catalysts for oxidation process due to their synergistic bi-functional mechanism, ability to dissociate molecular oxygen at low temperature and superb adsorption of both atomic oxygen and CO. In this study, we synthesized titanium dioxide supported platinum-tin bimetallic catalyst for low temperature CO oxidation process with different amount of tin. Titanium dioxide not only provides oxygen to active sites due to its abundant oxygen vacancies, but also prevents metal sintering of active platinum nanoparticles. We confirm that our titanium dioxide supported platinum-tin bimetallic catalysts show excellent performance for low temperature CO oxidation and the amount of tin on titanium dioxide support affects the catalytic performance of Pt based catalysts.

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청정일반

자일로스 유래 2-메틸퓨란으로부터 텅스테이트-지르코니아 금속 촉매를 이용한 선택적인 탄화수소의 생산

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온실가스 및 지구온난화의 우려가 증가함에 따라 화석연료를 대체할 지속가능한 액체 연료의 생산이 점점 중요해 지고 있다. 현재, 리그노셀룰로오스는 액체 바이오연료 생산 공정의 주요 원료 후보로 연구 되어지고 있으며, 리그노셀룰로오스의 부산물로 알려진 자일로스는 탈수, 중합, 수소화, 수첨탈산소화 등의 일련의 반응을 통하여 연료 및 유용한 화합물로 전환이 가능하다. 본 연구에서는 자일로스 유래 2-메틸퓨란으로부터 3단 연속 촉매 반응을 통하여 C5-15의 탄화수소를 선택적으로 생산하였다. 3단 연속 촉매 반응에는 텅스테이트-지르코니아 금속 촉매가 사용되었으며, 제조된 액체 바이오연료는 GC/MS, SimDist-GC, NMR, 원소분석 등으로 분석하였고, 촉매는 H2-TPR, XRD, TEM 등을 이용하여 분석하여, 각 반응 단계에서의 촉매의 역할을 확인하였다.

Keywords
리그노셀룰로오스, 자일로스, 2-메틸퓨란, 텅스테이트-지르코니아 금속 촉매

Fabrication of paper-based analysis device using PDMS coating

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Paper-based microfluidic analysis devices (μPADs) have recently attracted attention for their wide range of applications, including point-of-care diganostics and environmental material detection. To date, printing is the most adopted method due to its low cost and simple procedure. PDMS(polydimethylsiloxane) is the most popular polymer in microfluidic research due to its ease of fabrication, transparency, low electrical conductivity and elasticity. We applies a contact printing technique that uses plastic stamps to form a hydrophobic barrier using PDMA. We optimize the μPAD fabrication by controlling contact conditions including spin coating rate, reagent ratio, and contact time. These μPADs can be used for field analysis or even in developing countries.

미세플라스틱의 생태계 노출을 최소화하기 위한 하폐수 슬러지 관리전략

지 민 규 한국환경정책 · 평가연구원

A management strategy of wastewater sludge to reduce exposure of micro-plastics to the ecosystem

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미세플라스틱의 환경노출로 인한 생태계에 미치는 부정적인 영향들이 보고되면서 이의 발생 및 처리효율에 대한 연구가 하 · 폐수처리장을 중심으로 진행되었다. 하지만, 처리공정 내의 미세플라스틱이 대부분 슬러지에 침전되어 제거되는 것이 확인되었음에도 불구하고 슬러지 관리를 위한 국내 연구는 보고되지 않고 있다. 본 연구는 공공하수 및 폐수처리장 슬러지 유래 미세플라스틱의 환경노출을 최소화하고 이의 적정 관리방안을 마련하기 위한 기초 연구로서 수행되었다. 연구결과, 국내 공공하수처리장과 공공폐수처리장의 슬러지 발생량은 각각 연간 약 4백만톤 및 4십만톤으로 집계되었으며, 슬러지 내 미세플라스틱의 검출 현황은 g 당 최대 240±31개로 그 농도가 매우 높았다. 슬러지 처리방법으로 공공하수처리장의 슬러지는 재활용>소각>매립 등 순으로 비율이 높게 나타났으며, 공공폐수처리장의 경우는 재활용>연료화>매립 순으로 비율이 높게 나타났다. 미세플라스틱의 생태계 노출을 가중 시킬 수 있는 슬러지 처리방법은 매립 및 농업분야의 재이용 용도로 판단되며, 해당 방법은 국내 매립장의 수용 용량 부족 현상과 화학비료 및 가축분뇨 비료 등의 충분한 공급 현황을 고려할 때 그 필요성이 낮아 보인다. 대신 신재생에너지 정책과 연계하여 연료화, 에너지화 이용 방안을 확대하고 이외 건축자재 부원료 등의 활용을 적극적으로 모색하는 것이 지속가능한 환경보전 측면에서 보다 합리적일 것으로 예상된다. 향후 동 계획의 실효성과 관련 법 개정을 위한 주요 기초자료를 확보하기 위해서는 국내 슬러지 수요-공급 현황과 관리 계획의 환경적 영향 및 경제적 효과 등을 심도 있게 연구하는 과정이 필요할 것으로 판단된다.

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메탄올 수용액에서 팔라듐 촉매를 이용한 리그닌의 촉매화학적 분해

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방향족 화합물 단량체로 구성된 천연 고분자인 리그닌은 다른 산업 공정의 폐기물이 아니라 귀중한 화학물질, 연료 및 기타 응용 분야의 재생 가능한 공급원으로 사용될 수 있다. 귀금속과 고체산을 사용한 촉매화학적 분해방법이 이미 보고된 바 있으나 [1], 본 연구에서는 팔라듐 담지 촉매를 이용한 리그닌 분해 기술을 연구하고 공정 조건의 영향을 체계적으로 확인하였다. 반응중 리그닌 구조의 변화를 이해하기 위해 기체 크로마토그래피 및 GPC 분석 방법을 사용하여 생성물을 분석하였다.

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포도껍질 추출물과 편백나무 증류 추출물을 이용한 미백 화장품 소재 개발

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Development of cosmetic materials using grape skin extract and Chamaecyparis obtusa distillate extract

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포도껍질에 항산화 및 항암 효과가 우수하다고 알려진 안토시아닌 계열의 생리활성 물질들이 다량 함유되어 있음에도 불구하고, 이를 제대로 활용하지 못하고 폐기하고 있는 실정이다. 편백나무 증류 추출물은 다량의 터펜계 물질을 포함하고 있으며 피톤치드 물질로 강한 살균력을 나타내고, 최근에는 화장품 소재로도 관심을 받고 있다. 본 연구에서는 포도껍질 추출물, 편백나무 증류 추출물, 및 두 물질의 혼합액의 항산화 및 미백활성을 조사하였다. 건조된 포도껍질을 분쇄하여 얻은 분말에 증류수를 첨가하여 1시간 교반하였다. 여과를 통해 고형물을 제거하고 추출액을 얻었다. 분말 대 증류수 비에 따라 추출액의 회수율, 추출물에 함유된 총 페놀함량, 및 총 플라보노이드 함량을 측정하였다. 추출물의 농도를 변화시키며 DPPH 라디칼 소거활성, tyrosinase 저해도를 측정하였다. 포도껍질 추출물의 항산화 활성도(DPPH 라디칼 소거활성)은 70.5%로 우수하였지만 미백활성도(tyrosinase 저해도)는 21.1%로 비교적 낮았다. 반면 편백나무 추출물의 항산화활성도는 1.6%로 매우 낮았으나 미백활성도는 86.5%로 매우 높았다. 포도껍질 추출물(46 mg/mL)에 편백나무 증류 추출물 함량을 변화시키며 같은 실험을 반복하였다. 편백수 10% 혼합액의 DPPH 라디칼 소거활성과 tyrosianse 저해활성은 각각 74%와 49%였다. 편백수 30% 혼합액의 DPPH 라디칼 소거활성과 tyrosianse 저해활성은 각각 54%와 77%였다. 본 결과는 두 종류 추출액 혼합물이 기능성 화장품의 좋은 원료를 사용될 수 있음을 시사한다.

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Drying and Micronization of Ecamsule using Supercritical Antisolvent Method

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Ecamsule (tetrephthalylidene dicamphor sulfornic acid, C28H34O8S2), also known as Mexoryl SX, is a water-soluble and photostable organic UVA sunscreen agent [1]. Ethanol was used during the acidification step of the ecamsule synthesis process to produce light-yellow ecamsule powder. Because the ecamsule powder used in sunscreen product formulations should be highly pure and completely dry, ethanol should be almost completely removed from ecamsule–ethanol solutions. Typically, ethanol is separated from ecamsule–ethanol solutions using conventional techniques, such as vacuum distillation, superheated-steam drying, and hot-air oven drying. Conventional drying techniques present disadvantages, such as high energy consumption, high cost, and long duration. Moreover, they can cause damage to organic molecules via non-homogenous heat transfer, which reduces the ecamsule production profit. Therefore, the development of a fast, complete, energy efficient, and inexpensive alternative drying technique for the separation of ethanol from ecamsule–ethanol solutions without damaging the chemical structure of ecamsule, is highly desirable. In this study, we demonstrated that the supercritical antisolvent (SAS) technique with supercritical carbon dioxide (scCO2) as the antisolvent can be used to obtain completely dry and uniform micronized ecamsule powder from dilute ecamsule-ethanol solution with high recovery. The effects of different operating parameters, such as temperature, pressure, initial concentration of ecamsule solution, and solution flow rate on the recovery yield, ethanol removal efficiency, surface morphology, particle size, and chemical, thermal, and textural properties of dry ecamsule powder were investigated. To elucidate the ecamsule precipitation mechanism during the SAS process, the Hansen solubility parameters (HSPs) and relative energy differences were used to analyze the solubility of ecamsule in scCO2–ethanol mixtures under the studied conditions.

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Subcritical Water Extraction of Highly Bioactive Compounds from Red Ginseng Marc and Their Antioxidant Activities

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Although red ginseng marc (RGM) is a by-product obtained during manufacturing of various commercial ginseng products, it still contains various bioactive compounds such as saponins, proteins, and polysaccharides [1]. Extracts recovered from RGM have been demonstrated to possess several functionalities and bioactivities, which are useful for numerous applications in food, nutraceutical, pharmaceutical products, and biomedicine. Despite of its potential health benefits, RGM has been routinely discards as a waste or applied as a low-value products of animal feeds and fertilizers currently. Several processes have been developed for obtaining valuable compounds from by-products and residues, among of which subcritical water extraction (SWE) is considered as a green alternative that shows high promise from both a technical and economical perspective [2]. However, the use of SCW for the recovery of highly bioactive compounds from RGM is limited. Therefore, the main objectives of this study were to determine the efficiency of the SWE technique in the extraction of biologically active compounds from RGM powder and to gain insight into the mechanism of reactive extraction. We explored a range of extraction temperatures, pressures, times and stirring speeds, particle sizes of RGM, and ratios of RGM to water loading in order to maximize the yield and bioactive activity of the extract. The antioxidant capacities of the extracts were assessed using three in vitro methods: 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, Trolox equivalent antioxidant capacity (TEAC/ABTS) assay, and ferric reducing antioxidant power (FRAP) assay to compare the antioxidant activity values obtained using these methods.

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Operational parameters optimization of newly developed online system for water toxicity assessment using sulfur oxidizing bacteria and RSM

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In this study a newly developed online system for assessing the toxicity of heavy metals based on EC values was introduced using Sulfur oxidizing bacteria (SOB). The EC probe was fixed with 7 mL capacity acrylic reactor connected with computer program for the generation of online graph. For optimization studies Box-Behnken design (BBD) module of response surface methodology (RSM) was used and selected three parameters were temperature (25°C ~ 35°C), media volume (1.5 ~ 3 mL) and amount of SOB (1 ~ 3g). The other configuration of experiments were SOB particle 0.5 ~ 2 μm size, 5 mL/min air flow and run for 30 min/feeding cycle. The $Cr6+$ used as a model toxicant and to find the EC50 values using different concentrations of $Cr6+$ (0 ~ 25ppm $Cr6+$). The statistical significance of experiments were analyzed by analysis of variance (ANOVA) and results showed that the model is significant for the experiment design of newly developed small vials reactor. The lowest EC50 value of 4ppm $Cr6+$ was found at the condition of 30°C, 2g SOB and 2 mL of media. The desirability value of 1 showed 42 combination of independent variables and only one combination (SOB amount 1.67, media volume 2.32 and temperature 31.33 °C) was selected for validation of mode. The validation of results show 3.41 ppm $Cr6+$ which is well under the 5% range and this also verify the model suitabiltiy. The results of this study showed that new machine is able to assess the toxicity in 30 min time and applied RSM model are also able to optimize the operational parameters of the newly developed toxicity measuring system. The method also found simple, robust, sensitive and comparable to other biological assays available.

Study on the effect of IrO2/TiO2 catalyst coated Titanium PTL on PEMWE process through electrolysis performance and impedance analysis

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Porous transport layer (PTL) in polymer electrolyte membrane water electrolysis (PEMWE) systems is an important component, which not only works as current distribution factor but also provides a porous media for mass transport. PTL surface passivation occurs commonly when the PEMWE cell operating under harsh conditions (high temperature, acidic environment) and long-term operation. One of the solutions for preventing surface passivation is coating a stable thin layer of catalyst on PTL. In this study, by combining two methods: spray-coating and thermal treatment, a thin layer of IrO2/TiO2 was deposited on the surface of the Ti-PTL to prevent the passivation and improve the performance of the PEM electrolyzer. The IrO2 layer was expected to reduce the cell Ohmic resistance and improve the stability of the Ti-PTL due to the preventing of TiO2 forming. By changing the IrO2 catalyst loading on the surface of the Ti-PTL, 3 samples with different catalyst loading (0.3 mg/cm2, 0.7 mg/cm2, 1.3mg/cm2) and pristine PTL were investigated to access the effect of catalyst loading on the water electrolysis cell performance. The impedance results indicated that cell Ohmic resistance and impedance with coated PTLs were slightly lower than the one with pristine commercial PTL. Moreover, the polarization curve results showed that cell performances of coated PTLs were better than pristine PTL and increased with the increase of catalyst loading on the surface of PTLs.

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해조류 유래 항균 기능성 필름 합성

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Synthesis of antibacterial film derived from seaweed

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본 연구에서는 해조류로부터 얻어진 알긴산 나트륨(sodium alginate, SA)과 캐슈넛 껍질액(CNSL) 두 가지 바이오 소재를 활용하여 항균성 바이오 필름을 제작하였다. 알긴산 나트륨(sodium alginate, SA)은 3세대 바이오매스인 해조류에서 쉽게 얻을 수 있는 주 구성성분이며 생분해성, 생체 친화성, 환경 친화성 고분자 중 하나로 흡수력이 뛰어나고 방사성을 가진다는 장점이 있어 다방면에 응용이 가능하다.[1] 생분해성, 재생 가능성, 합리적 가격 등 다양한 장점을 가진 식물성 오일 중 하나인 캐슈넛 껍질액은 불포화 알킬기를 가진 페놀 계 혼합물로 구성되어 있는 재생가능한 자원이다. 또한, 특유의 분자구조로 인해 기타 바이오매스와는 달리 항균성을 부여할 수 있기에 식품용 및 의학용 등 다방면에 응용할 수 있는 잠재력과 활용도가 높은 물질이다.[2] 본 연구에서는 필름의 기계적 물성을 보완하고자 수용성 친환경 고분자인 폴리비닐알코올(poly (vinyl alcohol), PVA)을 일정 비율(10−50 wt%)로 혼합하고 가교제를 이용하여 항균 기능성을 가진 바이오 필름을 제조하였다. 제조된 필름의 물리화학적 특성을 알아보기 위해 FT−IR, TG−DTA, 팽윤도 측정, 인장 강도 및 연신율 측정을 진행하였으며, 질병과 관련된 기본 균주 2종인 대장균과 황색 포도상구균을 활용하여 항균성 평가를 수행하였다. 본 연구의 결과를 통하여 식품, 생활용품 및 의약품 등에 접목시킬 수 있는 바이오매스 유래 친환경 항균 기능성 고분자에 대한 연구에 기여하고자 한다.

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각각 다른 양의 H-ZSM-5 zeolite가 코팅 된 물결형 마이크로채널 반응기를 이용한 methylcyclohexane 흡열 분해 연구

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A study on endothermic decomposition of methylcyclohexane using a wavy form microchannel reactor coated with different amounts of H-ZSM-5 zeolite

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비행속도가 마하 5 이상인 극초음속 비행체는 비행 중 공기와의 마찰열로 인해 비행체 내구성의 저하 및 연소실 주입구 막힘 등과 같은 심각한 문제에 직면하고 있다. 앞서 언급한 문제들을 해결하기 위한 방법으로 본 연구에서는 흡열 연료 분해를 이용한 냉각기술을 적용하였다. 흡열 연료 분해 반응을 위한 모델 흡열 연료로서 methylcyclohexane (MCH)를 선택하였다. MCH 흡열 분해 반응은 온도가 550℃, 압력이 5 MPa인 초임계 조건에서 30분간 수행되었다. 흡열 연료 분해 성능을 향상시키기 위해 촉매로서 H-ZSM-5 zeolite를 이용하였으며, 유로 개선을 위해 일반적인 튜브 반응기가 아닌 물결형 마이크로채널 반응기를 선택하였다. 반응기 표면 위에 각각 다른 양의 촉매를 코팅하기 위해 Si 바인더를 이용한 바인더 코팅을 각각 다른 횟수별로 수행하였다. 반응기 표면 위로 코팅 된 촉매를 확인하기 위해 field emission scanning electron microscopy (FE-SEM), energy dispersive spectroscopy (EDS) 분석을 수행하였다. 바인더 코팅 횟수가 증가함에 따라 반응기에 담지 되는 촉매의 양은 증가하였으며, 본 연구에서는 촉매 양에 따른 MCH 흡열 분해 성능과 촉매 비활성화 관계를 확인하였다. 결과적으로 촉매의 양이 증가함에 따라 흡열 분해 성능은 증가하였지만, 반응 시간이 지남에 따라 촉매 비활성화는 더욱 심해졌으므로 두 결과는 서로 상충관계에 있음을 확인하였다.

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리튬-황 전지용 플렉서블 S-NiO-CNT 복합전극의 전기화학적 특성

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Electrochemical Properties of Freestanding Flexible Sulfur-NiO-Carbon nanotube Composite for Lithium-Sulfur Batteries

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가볍고 자원이 풍부한 황을 양극 활물질로 사용하는 리튬-황 전지는 높은 이론 용량 (1675 mAh g)과 높은 에너지 밀도 (2600 Wh kg)로 인하여 유망한 차세대 배터리로 각광받고 있다[1,2]. 하지만 충방전 과정 중 폴리설파이드의 용출로 인한 셔틀반응이 음극의 부식과 활물질의 손실이 초래하여 전지의 성능을 저하시킨다. 양극활물질인 황은 절연체에 가까운 낮은 전기전도도 (5 × 10 S cm)로 필히 도전성 물질과 함께 사용하여야 하며 충방전시 부피 팽창으로 인해 전극의 구조붕괴가 발생한다[3,4]. 따라서 전극에 생성된 균열은 활물질의 이용률을 저하시키고 용량 감소 및 배터리의 고장이 발생된다[5]. 본 연구에서는 부피 팽창에 의한 전극 구조 붕괴 현상을 억제하고자 필터링 방법으로 제조한 유연한 황/탄소나노튜브 (S/CNT) 전극을 제조하였고 충방전 시 생성되는 리튬 폴리설파이드의 전해질로의 용출을 억제하여 셔틀 효과를 차단하고자 수열반응으로 합성한 다공성 NiO 나노분말을 도입하였다. 그 결과 NiO를 도입하지 않은 S/CNT 전극을 이용한 리튬-황 전지의 초기 방전용량은 794.4 mAh g, 100사이클 후 583.2 mAh g로 나타났고, NiO를 도입함으로써 초기용량은 1050.2 mAh g으로 증가하였으며 유지율도 NiO를 도입하지 않은 S/CNT 전극은 73%인 것에 비해 92%로 높게 나타났다.

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Resolution and Resin Comparison of Three-Dimension Printing Technologies

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With the dramatic increment of complexity, more microfluidic devices require 3D structures. The traditional multi-step photolithography is time-consumine and labor-intensive and also requies precise alignment during the fabrication of microfluidic devices. A direct experimental comparison of the two 3D printing technologies domination microfluidics was conducted using a open channel microfluidic device, the design of which was optimized for each printer: Polyjet, digital light processing stereo-lithography(DLP-SLA). Printer performance was evaluated in terms of feature size for mass manufacturing. Polyjet was suitable for microfluidic fabrication with minimum features of >500μm. DLP-SLA fabricatied a minimum channel size >100μm. Compared with Polyjet, resolution better than Polyjet and showed suitable for microfluidic fabrication. Microfluidic application requring precise control of flow. In discussion of limitations channel size of these printers, the various size width of high in 3D-printed microchannels should find wide applicablity in drug delivery, tissue engineering, organ-on-a-chip platforms.

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철 질화물-탄소 복합체 구조의 제조 및 아연공기전지의 산소환원반응용 촉매로의 응용

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Preparation and application of iron-nitrogen-carbon composite as the electrocatalyst for oxygen reduction reaction of zinc-air battery

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아연공기전지는 에너지 밀도와 에너지 변환 효율이 높고 에너지 변환과정에서 환경오염 물질을 발생시키지 않는 에너지 변환장치로서 주목받고 있다. 그러나 양극에서 산소환원반응이 일어날 때 높은 과전위로 원하는 출력을 내기 위해서 백금과 같은 많은 양의 귀금속 촉매가 필요하다. 이러한 귀금속 촉매의 가격 한계를 해결하기 위하여 전이금속과 질소가 활성점으로 작용하는 우수한 전기화학적 성능을 가진 비귀금속 촉매의 연구가 이루어지고 있으며 최근 비귀금속 촉매의 활성점이 원자수준으로 분산될 경우 높은 산소환원반응 활성을 나타낸다는 연구결과가 보고되었다.

본 연구에서는 탄소지지체인 열박리된 그래핀 산화물에 산소환원반응 활성이 우수하다고 알려진 매크로사이클 구조의 철-프탈로시아닌(FePc)를 흡착시키고 암모니아 분위기로 열처리하여 철 질화물-탄소 복합체 구조의 촉매를 제조하였다. 탄소지지체와 금속전구체의 자가정렬을 통해 내구성이 향상되고 촉매구조를 안정화하였다. 이때 촉매가 고온에서 노출되는 시간을 조절하여 고온 열처리 후에도 원자수준으로 고분산된 활성점을 형성하였다. 제조된 촉매는 우수한 산소환원반응 활성과 높은 내구성을 나타내었다.

메탄의 저온 수증기 개질 반응을 위한 Ni 기반 촉매의 다양한 금속 산화물 조촉매에 따른 영향

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Effects of Various Metal Oxide Promoters on Ni-Based Catalyst for Low-Temperature Steam Reforming of Methane

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본 연구에서는 메탄의 저온 수증기 개질(Low−temperature steam reforming of methane) 반응에 다양한 금속 산화물 조촉매(MgO, CaO, La2O3)가 첨가된 Ni 기반 촉매를 적용하였다. 메탄의 저온 수증기 개질 반응 결과, 제조된 촉매 중 Ni−La2O3−Ce0.8Zr0.2O2 촉매가 621,704h−1의 매우 높은 공간속도(GHSV, Gas Hourly Space Velocity)에서 높은 활성을 나타내었다. 또한 촉매의 안정성 평가를 위해 저온의 수증기 개질 반응에서 공급 가스비(CH4:H2O:N2 =1:1:3), 온도 = 600 oC, GHSV = 621,704h−1 조건에 적용한 결과, Ni−La2O3−Ce0.8Zr0.2O2 촉매가 비활성화 없이 12시간 동안 높은 활성과 안정성을 나타내었다. 이는 Ni−La2O3−Ce0.8Zr0.2O2 촉매의 높은 Ni 분산도, La2O3의 강한 염기성 그리고 Ni과 La2O3 사이의 상호작용 강화에 의한 결과로 보여진다. 따라서, 메탄의 저온 수증기 개질 반응에 Ni−La2O3−Ce0.8Zr0.2O2 촉매가 가장 적합한 촉매로 판단된다.

산소 환원 반응을 위한 백금-니켈 중공형 입자의 합성과 구조 제어 메커니즘 규명

김 동 건, 이 수 진, 정 성 권, 이 은 희, 정 혜 원, 김 필
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Synthesis of Pt-Ni hollow nanoparticles for oxygen reduction reaction and investigation of structure control mechanism

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백금 담지 촉매는 높은 산소 환원 반응 활성을 나타내어 양이온 교환 막 연료전지의 전극 촉매로써 주로 사용되고 있다. 하지만 상용 백금 촉매는 높은 가격 및 연료전지 작동 과정에서 나타나는 성능 저하 문제를 가지고 있다. 백금 입자의 나노 구조 제어를 통해 기존 촉매의 문제를 극복하고자 하는 연구가 많이 진행되었으며, 중공형 구조로 백금 합금 입자를 제어함으로써 산소 환원 반응 활성 및 내구성을 크게 증대시킬 수 있는 것으로 알려져 있다. 그러나 중공형 구조의 백금 합금 입자를 형성하기 위한 기존의 방법은 복잡한 단계를 거쳐야 하는 단점이 존재한다. 따라서 간단한 방법을 통한 중공형 입자 촉매의 개발과 나노 구조 제어를 위한 입자의 형성 메커니즘 연구가 필요하다.

본 연구에서는 다중 금속 전구체의 환원 속도 차이를 이용하여 단일반응을 통해 중공형 구조의 촉매를 합성하였으며, 촉매의 합성 시간에 따른 형상 비교를 통하여 입자 형성 메커니즘을 규명하였다. 그리고 합성된 촉매의 특성을 분석하고 과염소산 용액에서의 산소 환원 성능 평가를 진행하였다.

탄소 쉘이 코팅된 질소종의 Co-N-C 촉매의 제조 및 산소환원반응 성능평가

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Preparation and characterization of Co-N-C with Carbon Shell-Coated Nitrogen Species for oxygen reduction reaction

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수소연료전지는 높은 에너지 밀도와 친환경적인 시스템으로 차세대 에너지 변환 장치로 주목받고 있다. 그러나 연료전지의 양극에서 일어나는 산소환원반응 메커니즘의 높은 과전위와 느린 반응속도 때문에 원하는 출력을 얻기 위해서 백금과 같은 다량의 귀금속 촉매가 필요하다. 이는 연료전지의 높은 시스템 가격의 원인이 된다. 연료전지의 가격 경쟁력을 높이기 위해 고가의 귀금속 촉매를 대체할 비귀금속 기반의 촉매 개발 연구가 진행되고 있다. 특히 질소종을 포함하는 비귀금속–탄소 복합체를 이용한 촉매는 산소환원반응 성능이 우수하여 귀금속 촉매를 대체할 촉매로써 주목받고 있다.

본 연구에서는 탄소 전구체인 Graphene oxide에 코발트를 배위시킨 뒤 열분해를 통해 탄소 쉘이 코팅된 질소종을 포함하는 Co–N–C 구조의 촉매를 합성하였다. 산소환원반응 성능증대를 위해 합성조건(합성온도 및 열처리 시간)을 조절하여 촉매를 제조하였고 XRD, TEM 등의 물성분석과 전기화학적 성능평가를 수행하였다.

실리콘/탄소 나노복합체의 공극 부피에 따른 리튬 이차전지 음극활물질 성능 특성

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Performance characterization of silicon/carbon nanocomposite with buffer space for the anode materials of lithium ion batteries

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전기자동차와 소형 전자기기 시장의 성장으로 높은 에너지 밀도와 전력 밀도를 가진 리튬 이차전지에 대한 수요가 증가하고 있다. 이를 위해 양극, 음극 활물질의 다양한 연구가 진행 되고 있다. 그 중 흑연은 높은 전도도와 가격으로 상업적으로 가장 많이 사용되고 있다. 하지만 흑연의 여섯 개의 탄소 원자가 오직 한 개의 리튬 원자를 저장할 수 잇기 때문에 에너지 밀도를 높이는데 한계가 있다는 단점이 있다. 때문에 다양한 분야에 요구되는 높은 성능을 가진 리튬 이차전지를 위해 음극 활물질로 사용되던 기존 흑연을 대체할 필요성이 증가하게 되었다. 그 중 실리콘은 낮은 방전 전위와 흑연 대비 매우 높은 리튬 이온 저장용량을 가지고 있어 음극 활물질로서 흑연을 대체할 소재로 각광받고 있다. 하지만 실리콘은 리튬이온의 삽입과 탈리 과정에서 매우 큰 부피 팽창률을 가지고 있다는 단점이 있다. 이는 실리콘 입자가 표면의 물리적 응력을 받아 분쇄하게 되는 원인이 된다. 또한 분쇄되는 실리콘 입자는 불안정한 고체전해질 계면을 파괴해 지속적으로 전해질을 분해하게 만들어 사이클 안정성을 떨어지게 만든다. 이 같은 문제점을 해결하기 위해 다양한 연구가 진행되고 있다.

본 연구에서는 실리콘/탄소 구조의 공극이 존재하는 코어-쉘 나노 복합체를 제조해른 리튬 이차전지 음극활물질로서 공극 부피에 따른 특성을 평가한다. 탄소 쉘은 불안정한 고체 전해질 형성을 막고 전도도를 높여 리튬 이온의 빠른 확산을 촉진시킨다. 또한 실리콘과 탄소 사이에 존재하는 공극은 리튬 이온 삽입과정에서 발생하는 부피 팽창 응력을 감소시켜 사이클 안정성을 높이게 된다.

생물 소재를 전구체로 이용한 촉매담체 제조 및 특성분석

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Preparation and characterization of catalyst supports using the biomass precursors

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연료전지의 Anode 전극에는 연료의 산화를 촉진하기 위한 촉매층과 Cathode 전극에는 산화제의 환원을 촉진하기 위한 촉매층이 존재한다. 이때 촉매의 담체로서 비 표면적과 전기전도성이 높은 탄소가 필요하다. 기존의 탄소 제조공정 중 석유정제 과정에서 발생하는 메탄, 일산화탄소, 이산화탄소는 지구 온난화와 대기 오염의 주범이 된다.

본 연구는 친환경적으로 탄소 담체를 제조하기 위해 다양한 생물 소재를 전구체로 사용하였다. 또한 전처리 조건을 세분화하여 고결정성을 갖는 담체 양산을 위한 최적화 조건을 도출하였다. 사용된 생물 소재는 Asparagus, 밀웜, Colostrum, Corynebacterium glutamicum 등이 있고 다양한 처리공정을 통해 생물 소재의 불순물을 제거하고 결정성을 높여 전극 촉매로서 이용 가능한 탄소 담체를 제조하였다. 제조된 탄소 담체는 XRD, TEM 등 물성 분석을 진행하였고 이 담체에 백금을 담지하여 촉매를 제조한 후, 전기화학성능 평가를 진행하였다.

무전해 도금으로 Pd가 코팅된 수소 분리막의 제조 및 특성

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Fabrication and Characteristic of Pd Coated Hydrogen Membrane with Electroless Plating

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지구온난화로 인한 기후 변화는 화석 연료에서 발생되는 이산화탄소가 원인으로 알려져 있다. 이러한 이산화탄소 배출량을 줄이기 위해 화석 연료를 대체하여 이산화탄소 배출이 없는 수소에너지 기술이 주목받고 있다. 이에 따라 수소를 사용하기 위해 고순도의 수소를 제조하는 기술 개발의 필요성이 대두되고 있다. 수소 제조 기술 중 분리막을 이용한 수소 분리/정제 기술은 설치비용이 낮고 공정이 간단하다는 장점이 있다. 수소분자는 금속 표면에서 흡착되어 해리되고 금속 격자 사이를 이동해 다시 수소 분자로 재결합되어 탈착되는 성질이 있다. 이러한 원리를 이용하여 지지체 표면에 금속을 코팅하여 수소를 분리시키는 수소 분리막 연구가 진행 중이다. 특히, 수소는 금속 중 팔라듐에서 높은 용해도와 이동도를 보이기 때문에 우수한 수소 투과 특성을 보인다. 본 연구에서는 무전해 도금으로 알루미나 중공사막 표면에 코팅하였다. XRD, SEM, EDS 분석을 통해 팔라듐 코팅 특성을 확인하였으며, 치밀 막 형성 여부를 파악하기 위해 진공펌프로 감압 후 치밀 막 테스트를 진행하였고, 수소 투과 실험을 수행하였다.

전이금속/알루미나 촉매를 이용한 trickle bed reactor 에서 1-methylnaphthalene 수소화 반응

오승교, 구희지, 한기보, 정병훈, 전종기 공주대학교, 고등기술연구원, 국방과학연구소

Hydrogenation of 1-Methylnaphthalene over Transition Metal/Alumina Catalysts in Trickle Bed Reactor

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다환식 방향족 탄화수소(Polycyclic aromatic hydrocarbons, PAHs)는 구조적 배열이 다른 2 개 이상의 융합 벤젠 고리를 포함하는 유기 화합물 계열이다[1]. PAHs는 독성, 발암성(carcinogenic), 기형유발효과(teratogenic effect)등과 문제로 주목을 받았다[2]. 열처리, 광분해, 화학적 산화 등과 같은 PAHs의 제거를 위해 제안되었지만, 이러한 공정은 느리고 에너지 소비가 많은 복잡한 기술이다[3]. 따라서, 활성금속이 담지된 촉매를 활용하여 PAHs의 수소화를 진행하는 연구들이 활발히 이루어졌다. 금속지지 촉매는 불균일 수소화 반응과 같은 촉매 분야[4-6]에 널리 사용되는 것으로 잘 알려져 있다. 촉매는 알루미나 지지체에 전이금속을 담지하여 제조하였으며, BET, TPD, TPR 등을 통해 촉매 특성을 분석하였다. 본 연구에서는 PAHs의 model reactant로써 1-methylnaphthalene을 이용하여 Trickle-bed reactor 반응기를 통해 촉매의 방향족 화합물의 수소화 능력을 평가하였다.

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미세먼지 저감을 위한 TiO2-mayenite의 물성특성 및 de NOx 시험성능평가

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Physical properties and de NOx performance evaluation of TiO2-mayenite for reducing particulate matter

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대기 환경오염으로 인한 공기 중의 미세먼지 증가와 이로 인한 국민건강의 위험성이 위협받고 있다. 미세먼지의 피해를 줄이기 위한 노력에도 불구하고 미세먼지(PM10)의 국내배출량은 지속적인 감소를 보이고 있으나 초미세먼지(PM2.5)의 농도는 여전히 높은 수준이고 개선하기 어려운 상황이다. 최근 초미세먼지의 대표적인 원인물질인 NOx를 제거할 수 있는 TiO2-매개담체를 사용한 다공성 콘크리트 개발에 관한 연구가 이루어지고 있다. 이러한 다공성 콘크리트에 TiO2-매개담체를 적용할 경우, 도심의 도로, 터널, 버스정류장 및 건물의 외벽 등에 적용하여 공기 중에 존재하는 NOx를 광촉매 반응을 통하여 전환하고 쉽게 제거할 수 있는 장점을 가지고 있다. 본 연구에서는 다공성 콘크리트 내에 광촉매의 분산성을 높이기 위하여 TiO2에 매개담체(mayenite)를 활용하는 연구를 수행하였다. TiO2-매개담체(mayenite)는 sol-gel법이 사용되었으며, gel 상태의 TiO2를 mayenite에 혼합하여 제조하였다. TiO2와 mayenite의 비율을 조절하여 시료를 합성하였으며, BET, TGA, XRD 등을 통해 특성분석을 수행하였다. 또한 KS L ISO 22197-1 질소산화물 제거 성능평가를 통해 최적의 TiO2-mayenite 비율을 결정하고자 하였다.

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Sustainable Synthesis of CoNi/MgAl2O4 Catalyst for Efficient Steam Reforming of Methane

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Ni-based catalysts are the most promising noble-metal free catalysts for catalyzing the steam reforming of methane (SRM). However, they tend to deactivate due to the coke deposition. Adding another element to Ni has been reported to promote the catalytic activity and coke resistance. Herein, we report a one-pot synthetic approach for fabricating CoNi/MgAl2O4 catalyst. The addition of Co to Ni has been explored to greatly enhance the catalytic performance and coke resistance when the catalyst applied for the SRM reaction. At Co/Ni weight ratio of 1/6, the catalyst displayed a significant enhancement in the CH4 conversion efficiency (82.7%), comparing to 59.8% for the catalyst prepared in the absence of Co. More importantly, it showed better resistance to carbon deposition. The great improvement in the performance as a result of adding Co, is due to the synergistic effect between the different metallic components, and strengthening the interaction between the active metals and support. The insights obtained from this study may have broad applications in developing highly stable CoNi based catalysts for high-temperature reactions.

Equilibrium behavior of high-pressure binary mixture for the allyl methacrylate and vinyl methacrylate under CO2

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The equilibrium solubility and thermodynamic properties for the two-component mixture of allyl methacrylate and vinyl methacrylate in supercritical CO2 were reported. Solubility determinations were performed through the synthetic method at T = (313.2 to 393.2) K and p = (4.01 to 16.27) MPa. The obtained results indicated that the solubility of supercritical CO2 was found to increase monotonically with the augmented of system temperatures and mole fraction of (allyl methacrylate and vinyl methacrylate) in binary (solute + solvent) mixtures.

The solubility curve of allyl methacrylate and vinyl methacrylate in the carbon dioxide + allyl methacrylate and carbon dioxide + vinyl methacrylate systems increases as the temperature increases at a constant pressure. The carbon dioxide + allyl methacrylate and carbon dioxide + vinyl methacrylate systems exhibit type-I phase behavior. Moreover, experimental solubility was adequately correlated with the Peng-Robinson equation of state. RMSD for the carbon dioxide + allyl methacrylate [kij=0.035, ηij=-0.035] and carbon dioxide + vinyl methacrylate [kij=0.032, ηij=-0.015] systems using two parameters determined at 353.2 K were 8.02 % and 4.32 %, respectively. Also, RMSD of carbon dioxide + allyl methacrylate system predicted by adjusted factors at the each temperatures was 4.11 %.

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황산(H2SO4)을 이용한 고체 고분자 전해질 수전해 Anode 확산층 표면 제어

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Surface control of anode porous transport layer of PEMWE using Sulfuric acid

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최근 지속되고 있는 화석연료의 고갈우려와 지구온난화를 가속시키는 온실가스 배출로 인해 당사국총회(COP21, 2015년12)에서는 세계 기후변화대응을 규정한 파리협정이 체결되었으며, 2020년 이후 모든 당사국(119개국)이 기후변화대응에 동참하도록 규정하였다. 이에 따라 온실가스를 배출하지 않는 청정에너지원인 그린수소 기술에 대한 중요성이 강조되고있다. 그린수소 기술인 물을 전기분해하여 수소를 얻는 수전해 기술은 향후 미래 에너지원으로 각광받고 있다. 본 연구에서는 고체 고분자 전해질 수전해 셀 구성요소 중 하나인 확산층의 표면을 화학적 처리를 통해 제어하여 과전압을 줄이고 성능과 안정성을 높이는 연구를 진행하였다. 그 중 확산층 표면 특성 중 하나인 친수성을 개선하고자 하였고 화학적 방법으로 황산처리 이용하였다. 6 M 황산을 40~90 ℃로 준비하여 각각 20분 동안 처리하였다. 처리 후 질량을 측정해 처리 전과 비교하였으며 친수성 정도를 접촉각을 측정하여 확인하였다. 또한 SEM, XPS 분석을 통하여 물리화학적 분석을 진행하였으며 I−V polarization, impedance 측정을 진행하여 전기화학적으로 성능 개선 여부를 분석하였다. 접촉각 측정 결과 40~50 ℃에서 질량 및 친수성 정도에서 큰 변화가 없었으며 60~90 ℃까지 질량 변화 및 친수성이 개선되는 모습을 확인할 수 있었다. 또한 60 ℃ 이후 높은 온도에서 황산 처리를 진행 할수록 성능 개선 폭이 높아진 것을 확인할 수 있었다. SEM 및 XPS 결과 다공성 및 비표면적이 증가하는 모습이 확인되었으며 산소 관능기 양이 증가하는 경향을 보였다.

Fabrication of zein and κ-carrageenan colloidal particles for encapsulation of quercetin: In-vitro release behavior and antioxidant activities

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The present work aims to prepare and stabilize quercetin (Q) loaded zein colloidal nanoparticles using κ-carrageenan (KC) as a stabilizer. A simple antisolvent precipitation method was used to fabricate the zein-KC colloidal nanoparticles at pH 5.0. The findings revealed that the newly prepared Q-loaded zein-KC complex colloidal particles had spherical shapes, a particle size below ~300.0 nm, a high magnitude of negative zeta potential (~-45.0 mV) and encapsulation efficiency of 62.0%. In aqueous environments, the anionic KC coating on the surface of zein colloidal particles modified the particulate and physicochemical properties of the encapsulated Q and enhanced its water dispersibility, thermal stability, and pH-mediated controlled release.The observed improvements were ascribed to hydrogen bonding, hydrophobic and electrostatic interactions among Q, zein, and KC. In addition, Q-loaded zein-KC complex colloidal particles demonstrated strong antioxidant activity. KC coated zein colloidal particles, therefore, have great potential for use in hydrophobic nutraceutical encapsulation.

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막 축전식 탈염 공정의 정전류 및 정전압 운전 특성 연구

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Constant Current and Constant Voltage Operation Characteristics of Membrane Capacitive Deionization

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축전식 탈염(Capacitive Deionization, CDI)기술은 역삼투, 열증류 및 전기투석법에 비해 상대적으로 낮은 에너지를 소비하는 친환경 공정으로 알려져 있다. CDI 공정에는 다공성 탄소구조체들이 전극재료로 보편적으로 사용되고 있으며 특히 이온교환막(Ion exchange membrane)이 적용된 멤브레인 탈염공정(MCDI)은 기존 CDI 공정에 비해 탈염효율이 높은 특성을 나타낸다. 그리고 이러한 CDI와 MCDI 공정에서는 정전류(CC: Constant Current)와 정전압(CV: Constant Voltage)공급 운전 방식이 보편적으로 활용된다. 따라서 본 연구에서는 최대허용전류(MAC: Maximum Allowable Charge) 이론을 기반으로 하여 정전류공급과 정전압운전 방식 실험을 수행하고 최적의 운전 방법을 비교하였다. 실험을 수행한 조건은 NaCl 용액을 일정 유량(0.02 l/min)과 일정 유입 농도(1000 ppm)로 하여 CC 운전은 100~400 mA의 범위에서 수행하였으며, CV 운전의 경우에는 0.25~1.0 V인 조건에서 실험하였다. 그리고 실험 결과는 Improved modified Donnan 이론과 Nernst−Planck식을 이용한 동적 이온 전달 모델(Dynamic Ion Transport Model)로 CC 및 CV 조건의 MCDI 공정의 농도 변화를 살펴보았다.

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High-Throughput Discovery of MOF for Ethane/Ethylene Separation: Molecular/Process Simulation and Experimental Validation

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Ethylene (C2H4) is one of the most important feedstock in petrochemical industries and is usually produced by the thermal cracking of hydrocarbons. This process inevitably yields ethane (C2H6) and the removal of ethane is one of the most challenging separation tasks due to their similar physicochemical properties. For the separation of ethane/ethylene mixture, conventional cryogenic distillation processes can be replaced if an energy-efficient separation technology can be developed such as adsorption-based separation. The performance of an adsorption-based separation process depends critically on the development of advanced adsorbent materials that can selectively adsorb ethane over ethylene.

Recently, metal-organic frameworks (MOFs) have attracted much attention in hydrocarbon separation because of their high pore volumes, designable pore characteristics, and countless structural possibilities. In addition, high-purity ethylene can be obtained in a single step with MOFs that preferentially adsorb ethane over ethylene. In this work, we include process simulations in the high-throughput computational screening work to explore more than 14,000 MOFs in the CoRE MOF 2019 database, which finally provides the best performing adsorbents for C2H6/C2H4 separation. Grand canonical Monte Carlo (GCMC) simulation and ideal VSA simulation results show that top three MOFs (CEYPUT, CEYPUT01 and UFATEA01) have superior ethylene recovery compared with other MOFs in the CoRE MOF database. The discovered MOFs were synthesized for testing its feasibility. The test results reveal that UFATEA01[Ni(IN)2] survives due to their stabilities. Moreover, the potential energy surface analysis, adsorption energy distribution and DFT optimized configuration results illustrate the underlying mechanism of ethane-selective adsorption in Ni(IN)2. The separation performance is assessed by the ideal process simulation, which shows that Ni(IN)2 is superior to many of the adsorbent materials reported to date for ethane/ethylene separation.

Electrolyte-UNIQUAC model을 적용한 아민 혼합수용액에서 이산화탄소 용해도 실험 및 모델링

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Experimental and Modeling Study of CO2 Solubility in Blended Amine Aqueous Solution Using Electrolyte-UNIQUAC model

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This paper reports the measured experimental data for CO2 solubility in a blended amine aqueous solution (AMP+MDEA, MEA+AMP, DIPA+AMP). The CO2 solubility was measured at different amine mixing ratios (Amine1:Amine2:H2O = 9:21:70, 15:15:70, and 21:9:70 wt %) and absorption/desorption condition of temperatures (323.15 and 383.15 K). The successive substitution method [1] was used for calculating the mole fractions of all molecules and electrolytes (cations and anions) from the equilibrium, along with the material and charge balances. The electrolyte universal quasichemical, e-UNIQUAC suggested by osama et al. [2], model was used to investigate non-ideality in the liquid phase. Calculations of CO2 solubility and optimizations (parameter regression) were conducted by in-house model in MATLAB® 2020a version. Using the above mentioned thermodynamic models, the CO2 solubility behavior, such as the partial pressures of CO2 in the gas phase, mole fractions of all components in the liquid phase, pH variations, heats of absorption were estimated.

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Towards Accurate Prediction of Pore Size Distribution in Nanoporous Materials using Machine Learning

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Pore size distribution (PSD) is one of the most critical properties to characterize nanoporous materials, especially for chemical separation. The current state-of-the-art techniques for obtaining the PSD use an adsorption isotherm as an input to various methods, such as Horvath–Kawazoe (HK), Barrett–Joyner–Halenda (BJH), non-local density functional theory (NLDFT), and quench solid density functional theory (QSDFT), developed for idealized surfaces. The adsorption community has widely adopted and routinely used these methods in the literature to characterize new and already synthesized nanoporous materials. However, recent studies in the literature show that these well-established methods can be sensitive to small structural defects[2]. Toward this end, in this work, we developed a machine learning (ML) approach to predict the PSD of a class of nanoporous materials such as metal-organic frameworks. We compared and discussed the developed ML model with the current state-of-the-art methods.

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국내 화학물질 안전관리제도 특징과 시사점

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Characteristics and Implications of Chemical Safety Management System in Korea

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우리나라는 가습기살균제사고, 구미불산사고 등 대형 안전사고를 기점으로 화학물질 안전관리에 대한 사회적 인식이 크게 변화되었고, 이에 따라 기존 「유해화학물질법」을 「화학물질의 등록 및 평가 등에 관한 법률(이하 ’ 화평법 ‘)」과 「화학물질관리법(이하 ’ 화관법 ‘)」으로 제 · 개정하고 ’15년 1월부터 이원화하여 시행하고 있다. 화평법은 기업에서 제조 · 수입하는 화학물질의 등록을 의무화하고, 등록된 화학물질에 대하여 정부에서 평가 · 관리하는 제도로 ‘07년 EU REACH를 시작으로 미국, 일본, 중국, 대만, 터키 등 전세계적으로 확산하는 추세이다. 화관법은 유해화학물질을 취급하는 사업장의 안전관리를 위하여 영업허가, 화학사고예방관리계획서 작성 · 제출, 취급시설 설치 · 관리 기준 준수 등의 의무를 부여하는 제도로 가장 유사한 국외 제도로 EU의 「Seveso Directive III」 가 있다. 국내 화평법–화관법과 국외 화학물질 등록 · 평가제도–사업장 화학안전관리제도와 가장 큰 차이는 화평법과 화관법이 연계되어 있는 유해화학물질 지정–관리체계이다. 화평법에서 유해성심사를 거쳐 유독물질로 지정되거나, 위해성평가를 거쳐 제한 · 허가 · 금지물질로 지정되는 유해화학물질은 모두 화관법의 적용대상이 되는데 이러한 연계 체계를 가진 국가는 현재까지 우리나라가 유일한 것으로 파악된다. 유해성이 높은 유해화학물질의 안전관리 및 사고예방 측면에서 화관법의 적용대상으로 포함시키는 것이 타당할 수 있지만, 화학사고 위험성이 낮은 유독물질까지 화관법의 적용을 받아 엄격한 안전관리기준을 적용하는 것이 필요한지에 대해서는 고민해볼 필요가 있다.

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Thermodynamic performance evaluation for MEA/DIPA mixed amines from the perspective of a Vapor-Liquid Equilibrium

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This paper reports the newly measured experimental data for CO2 solubility in a blended aqueous solution of monoethanol amine (MEA) and di-isopropanol amine (DIPA) at different amine mixing ratios (MEA:DIPA:H2O = 9:21:70, 15:15:70, and 21:9:70 wt %) and working temperatures (323.15, 343.15, 373.15 and 383.15 K). Additionary, the ratio of 15:15 was conducted with different concentrations of water (60, 70, 80 wt.% H2O). The successive substitution method [1] was used for calculating the mole fractions of all molecules (four molecules) and electrolytes (three cations and five anions) from the equilibrium, along with the material and charge balance equations (12 equations). The Novel shortcut method suggested by Lee et al. [2] was used to investigate regeneration energy of stripper for process optimization. Using the above mentioned thermodynamic models, the partial pressures of CO2 in the gas phase, mole fractions of all components in the liquid phase, heats of absorption, and cyclic capacities of CO2 according to the absorption/desorption temperature and the blending ratio of MEA/DIPA/H2O were estimated.

Keywords

Monoethanolamine(MEA), Diisopropanolamine(DIPA), Activity coefficient models, CO2 solubility, Regeneration energy

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Three Blended Amine (MEA, DEA and TEA) 혼합수용액에서 혼합 비율이 이산화탄소 용해도에 미치는 영향

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The Effect of Mixing Ratio on CO2 Solubility in a Three Blended Aqueous Solution of MEA, DEA and TEA

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Amine solution as a chemical solvent is widely used in an absorption process for removal of acid gases from natural, refinery and synthesis gases. amines are classified into primary, secondary, tertiary, diamine and steric hindrance amine according to the sort of amine group. Among them, MEA (Monoethanolamine) is widely used as the solvent for the CO2 absorption process because of the absorption capacity and low cost. DEA (Diethanolamine) has lower reaction enthalpy and is less corrosive than MEA. TEA (Triethanolamine) is expected to increase CO2 loading ratio. CO2 absorption capacity, pH, liquid mole fraction and cyclic capacity are calculated using MATLAB-in-house model. Also, the liquid mole fraction is compared to the simulation result and NMR data in a liquid phase. Calculations of simulation results were conducted by MATLAB® 2020a version.

PTFE 필터용 촉매 제조 및 탈질 성능 평가

권병찬, 부진호, 강도형, 박노국, 이장훈, 황상연, 서명조
영남대학교 화학공학부, 다이텍연구원, 고등기술연구원, (주)마이크로원

Manufacture of Denitrification Catalyst for PTFE filter

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고온 연소공정에서 배출되는 질소산화물은 초미세먼지를 유발하는 전구물질로서 대기중으로 배출하기 이전에 처리되어야 되는데, 특히 소규모 연소공정의 후단에는 여전히 탈질공정이 적용되지 않고 있는 실정이다. 최근 선택적 비촉매 환원법(SNCR, selective non−catalytic reduction)에 의한 탈황공정은 고온에서 운전되며, 탈질효율이 60%정도여서 연소로에 직접 적용되는 SNCR과 더불어 후단에서 SCR공정에 의한 2차 처리가 요구된다. 이에 연소배가스 집진공정인 여과백에 탈질기능을 부가하여 질소산화물의 고도처리를 위한 촉매를 개발하였다. 집진용 여과백은 PTFE 소재의 부직포를 사용하였으며, 여기에 함침법으로 제조된 V2O5/TiO2 촉매를 코팅하여 집진과 질소산화물을 동시에 제거할 수 있는 필터를 제조하였다..

본 연구에서는 DeNOx용 V2O5/TiO2 촉매를 제조 후, 암모니아를 환원제로 사용하여 반응 온도에 따른 질소산화물의 제거능력을 측정하였다. 또한 제조된 촉매를 PTFE에 코팅 후 SEM, BET 등의 표면분석을 통하여 필터의 기공특성을 살펴보았다.

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Effect of the reduced iron species in fermentation of glycerol to 1,3-Propanediol using Klebsiella Pneumoniae L17

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1,3-Propanediol(1,3-PDO) is a high value-added product that used as adhesives, laminates, and food additives. For efficient production of 1,3-PDO, sustainable and non-toxic regeneration of NADH is of great importance. ZVI (Zero-Valent Iron) can provide reducing equivalent for 1,3-PDO synthesis from glycerol as an electron donor. Klebsiella pneumoniae has a 1,3-PDO production pathway from glycerol and has been extensively investigated as exoelectrogens. In this study, we attempt to produce 1,3-PDO from glycerol by using an electrochemically active strain, K. pneumoniae L17, and ZVI as an electron donor. As a result, the production of 1,3-PDO using ZVI has increased significantly to 24.23 ±1.33 mol/l. These results implicate that ZVI can regulate the bioconversion of electroactive strain such as K. pneumoniae L17, therefore improve glycerol conversion into value-added platform chemicals.

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VOC 촉매연소 시스템 개발

김효식, 김지현, 김진호, 강석환, 류재홍, 박노국 고등기술연구원, 영남대학교

Development of catalytic combustion system for VOC removal

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휘발성 유기화합물(VOCs)은 화학공장에서 배출되는 가장 일반적인 오염물질로서, 대기 중에서 광화학반응을 일으켜 스모그의 원인이 되는 오존 및 광화학 산화성 물징을 만들며 자동차에서 배출되는 연소 배기가스 중의 SOx, NOx와 함께 최근 심각한 대기오염의 주요인이 되는 물질로 주목받고 있다.

VOCs는 일반 탄화수소와 비균질 탄화수소로 분류하고 있는데, 일반 탄화수소에는 olefin계의 방향족 탄화수소(Benzene, Toluene, Xylene 등)와 paraffin계의 지방족 탄화수소를 포함하고 있으며, 비균질 탄화수소에는 알데하이드, 케톤류 등이 있다. 특히, 방향족 탄화수소는 인쇄, 세탁, 피혁, 테입 및 페인트 산업등 산업현장 전반에 결쳐 사용되는 물질로써 발암성, 백혈병, 중추신경 장애, 염색체 이상 등을 유발시키는가 하면, 염화탄화수소는 오존층 파괴와, 지구온난화, 그리고 광화학 스모그를 생성시켜 눈의 자극, 가시거리 저하, 동식물 및 농작물에 피해를 주고 있는 실정이다.

특히 이중에서도 방향족 탄화수소인 톨루엔은 인쇄, 세탁, 피혁, 테이프 및 페인트 산업등 산업현장 전반에 걸쳐 사용되어 2015년 기준 VOCs 총 연간 배출량은 100만톤을 초과하였으며, 방향족 유기화합물인 톨루엔의 배출기여도가 90%이상을 차지하고 있는 실정이다.

본 연구에서는 이러한 휘발성 유기화합물 중 톨루엔을 대상으로 촉매를 이용하여 연소반응을 제어함으로써 불완전 연소로 인한 그을음 및 미세먼지 발생을 억제하고, 연소반응에 따라 발생하는 열원을 안정적으로 공급할 수 있는 시스템에 대한 연구를 진행하였다.

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자가치유 기능 수분산 폴리우레탄의 합성 및 특성 연구

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Synthesis and Properties of waterborne polyurethane with self-healing function

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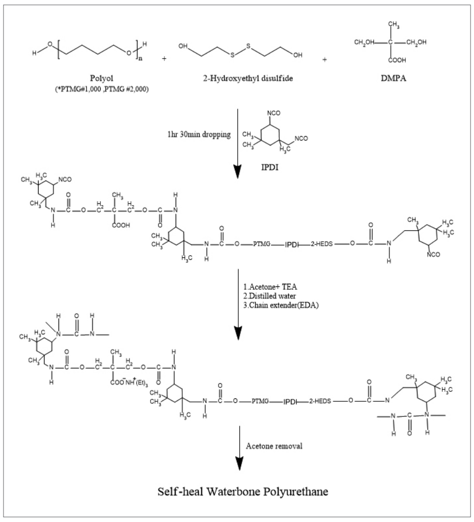
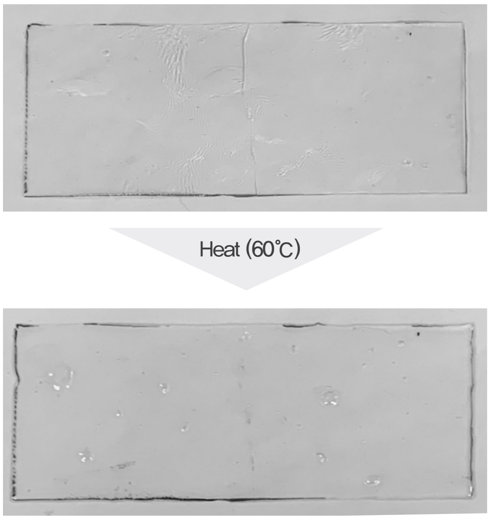
최근 들어 외부 환경에 의해 손상을 입은 고분자가 스스로 치유하는 자가치유 소재 개발에 대한 관심이 많아지고 있다. 특히 자동차, 의류, 신발 등 제품 겉 표면에 생긴 생활 스크래치나 손상은 자가치유를 통해 복원할 수 있다. 그리고 쓰레기 배출이 줄어들어 환경적인 이점 및 유지보수 비용의 절감을 기대할 수 있다.
본 연구에서는 유기용매의 방출이 없는 친환경적인 수분산 폴리우레탄에 이황화결합을 부여하여 열에 효과적으로 자가치유할 수 있도록 합성하고, 물리적 특성 및 자가치유 특성을 고찰하였다.
내마모성 및 내약품성이 우수한 Ether type 폴리올을 사용하였으며, 수지의 안정성을 위해 분자량 1000과 2000을 함량별로 혼합하였고, 이황화 결합으로 2−hydroxyethyl disulfide를 사용하여 수분산 폴리우레탄을 합성하였다.

또한 합성된 수분산 폴리우레탄의 물성은 Fourier transform−infrared spectroscopy(FT−IR)을 통해 WBPU의 합성 여부를 확인하였으며, universal testing machine(UTM)과 scanning electron microscope(SEM) 측정을 통해 물리적 특성 및 자가치유 특성을 확인하였다.



[합성 메커니즘]



[Film self healing test 전(위),후(아래)]

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시멘트 SCR 공정에 Urea 적용의 경제・환경적 영향 연구

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Study on the economic and environmental impact of applying Urea to the cement SCR process

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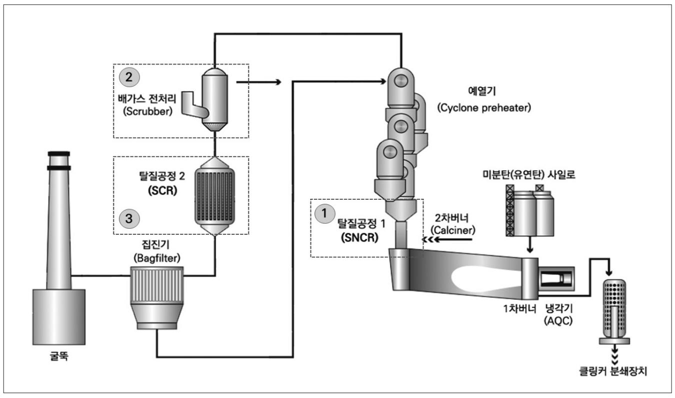
미세먼지 절감이 필요한 발전업과 시멘트제조업이 유사한 수준으로 배출하고 있어 미세먼지 대응체계 구축이 적극적으로 필요하다. 이에 환경부는 시멘트 사업장의 질소산화물 저감을 위해 협의체를 구성하고, 시멘트 공정의 특성을 적용한 SCR 공정 개발 연구를 시작 하였다[1].
미세먼지 생성물질인 질소산화물을 줄이기 위해 시멘트 업계도 기존 SNCR 공정 외에 SCR 공정을 적용하는 연구가 진행되고 있다.

따라서 본 연구에서는 선택적비촉매환원법(SNCR)과 선택적촉매환원법(SCR)이 동시 적용된 공정의 특성을 연구하였고, 시멘트 공정의 특성 상 많은 분진과 시멘트 분진이 환원제를 흡수하는 영향에 대한 사전 조사를 하였다. 이에 시멘트 현장에서 기존에 사용하지 않는 암모니아 대신 Urea를 사용 할 수 있는 조건에 대하여 질소산화물 배출량 허용량을 만족하기 위한 최적 온도와 분사량의 여러 가지 조건에 따른 case study를 진행하였다.

본 연구는 환경부 미세먼지 사각지대 해소 및 관리 실증화 기술개발사업의 지원에 의하여 연구되었으며 이에 감사드립니다(과제번호:202003060014).



[SNCR/SCR 연계 저감기술 적용 개념도]

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Keywords 시멘트 제조공정, DeNOx, SNCR, SCR, 공정모사

Bubble(or dew)-point behavior of binary system for the 2-(diethylamino)ethyl acrylate and 2-(diethylamino)ethyl methacrylate in supercritical carbon dioxide

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In this investigation, the equilibrium conditions of high pressure mixture for the 2-(diethylamino)ethyl acrylate and 2-(diethylamino)ethyl methacrylate in supercritical carbon dioxide are presented of (pressure + composition) space. Both mixtures (2-(diethylamino)ethyl acrylate + carbon dioxide) and (2-(diethylamino) ethyl methacrylate + carbon dioxide) were investigated at (313.2 to 393.2) K and at (5.0 to 20.9) MPa to get the phase equilibria data. The phase separation of (vapor + liquid) behavior for the 2-(diethylamino)ethyl acrylate and 2-(diethylamino)ethyl methacrylate play a momentous function as the organic solvents in a diversity of industrial processes. The two (2-(diethylamino)ethyl acrylate + carbon dioxide) and (2-(diethylamino) ethyl methacrylate + carbon dioxide) components have mixture critical curves that appears maxima in the (p-T) plot between the Tc (critical temperatures) of 2-(diethylamino)ethyl acrylate and carbon dioxide or 2-(diethylamino)ethyl methacrylate and carbon dioxide. The two component systems of (2-(diethylamino) ethyl acrylate + carbon dioxide) and (2-(diethylamino)ethyl methacrylate + carbon dioxide) mixture display type-I in simplest behavior. The experimental results for the (2-(diethylamino)ethyl acrylate + carbon dioxide) and (2-(diethylamino)ethyl methacrylate + carbon dioxide) are modelling with a general cubic equation of state containing the (kij, ηij) adjustable parameters.

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효율적인 SCR 공정 운용을 위한 시스템 개선 연구

김지현, 김진호, 김효식, 강석환, 류재홍 고등기술연구원

System improvement study for efficient SCR process operation

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대기환경오염물질인 질소산화물(NOx)을 제거하기 위해 화력발전소 보일러 후단에는 탈질설비인 SCR(Selective Catalytic Reduction) 공정이 구성되어 있다. 이때 SCR 공정의 운전 조건은 상압, 약 350℃이며, 촉매가 장입된 반응기 내부로 암모니아(NH3)를 분사되면서 선택적으로 환원반응이 발생하고 배가스 내 질소산화물(NOx)이 저감된다. 하지만 탈질설비로 유입되는 배가스의 경우 보일러 조건에 따라 조성이 변한다. 설비 운영에 있어 대기환경보전법에 따라 질소산화물 배출량이 규제되고 있기 때문에 NOx 저감율을 만족해야하며, 분사되는 암모니아 중 발생할 수 있는 미반응되는 양(이는 설비 내 부식 문제를 유발함)을 최소화해야한다. 이 두 가지 요소를 만족시키기 위한 효율적인 운용 방식을 구현하기 위하여 암모니아의 공급량을 진단하고 제어하고자 본 연구를 진행하였다. 본 연구에 사용된 설비에 발전소와 동일한 형태인 Plated type의 촉매를 장착하였으며, 배가스 처리 용량이 400 Nm3/h급인 SCR 설비를 구축하여 반응물인 NO와 NH3를 MFC로 조절하여 공급하였다. SCR 설비 전·후단에 분석라인을 통하여 반응물 농도 변화량을 관찰하였고, 변화량 데이터를 기준으로 암모니아 공급량 제어가 가능한지 살펴보았다.

본 연구는 2018년도 산업통상자원부의 재원으로 한국에너지기술평가원(KETEP)의 지원을 받아 수행한 결과입니다. (No.20181110100320)

One-pot conversion of alginic acid into furfural using Amberlyst-15 as a solid acid catalyst in γ-butyrolactone/water co-solvent system

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One-pot conversion of alginic acid, which was derived from brown algae, to furfural was investigated using various solid acid catalysts. Among the solid acid catalysts tested, Amberlyst-15 showed the highest activity in furfural production in aqueous media. When the effect of reaction media was examined, it was found that γ-butyrolactone/water co-solvent system was selected as the most appropriate system for the reaction. Maximum furfural yield of 32.2% was obtained using Amberlyst-15 at 210 °C for 20 min. Catalyst showed gradual deactivation behavior as the reaction proceeded, although the catalyst recovered its activity upon the simple treatment with sulfuric acid. N2 adsorption-desorption experiments, FT-IR, back titration, and CHNS analysis were applied to investigate the physicochemical property of post-reaction samples, confirming that the leaching of the active sulfonic acid group and decrease in acid density was the major cause of deactivation.

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Effect of Gallium modification methods and Regeneration on Co-aromatization of Methane and Propane over Gallium-modified ZSM-5 catalysts

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Methane, the major component of shale gas, is well known for its chemical inertness and its direct transformation to value-added products such as BTX proves to be greatly challenging. Non-oxidative methane aromatization requires high temperature(~700 oC), and the extreme reaction condition leads to practical limitations such as severe catalytic deactivation. The use of propane as a co-reactant lowers the thermodynamic barrier and the co-aromatization of methane and propane is feasible at lower temperatrue(~550 oC).

In this study, Ga-modified ZSM-5 catalysts were prepared by different methods(wetness impregnation, hydrothermal synthesis) and their performance in co-aromatization was investigated. Regeneration experiments were also carried out and each catalyst, which turned out to display distinct catalytic behavior, was characterized by XRD, BET, and Solid-state NMR.

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염기 촉매를 이용한 셀룰로오스와 선형 저밀도 폴리에틸렌 혼합열분해

류 혜 원, 김 도 희 서울대학교

Catalytic co-pyrolysis of cellulose and linear low-density polyethylene over MgO impregnated catalysts having different acid-base property

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Catalytic pyrolysis can be applied to upgrade the quality of pyrolysis product. In addition, the co-feeding of hydrogen sufficient plastics can increase the yields of aromatic hydrocarbons and calorific value of bio-oil[1]. Among various kinds of catalyst applied to the catalytic pyrolysis of biomass and biomass/plastic mixture, zeolites are known as the most efficient catalysts for producing aromatic compounds due to their proper shape selectivity and high acidity. Compared to zeolites, base catalysts are more resistant on the deposition of alkali metals to the catalysts. In addition, base catalysts prefer to form CO2 instead of CO and H2O formation than acid zeolites, suggesting the increase of carbon and hydrogen contents in product oil also by using base catalysts[2]. Especially, MgO is known as a cost-effective alkali metal which can decrease the corrosiveness of bio-oil by converting acids to ketones[3]. In this study, catalytic co-pyrolysis of cellulose and linear LLDPE over different MgO loaded catalysts (Bulk MgO, MgO/C, MgO/Al2O3, MgO/ZrO2) were investigated to know the effect of different supporting materials of MgO on the production of value-added bio-oil.

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CO2 Methanation Reaction over Noble Metal Catalysts Supported on Al@Al2O3 Core-Shell Microstructure with Controlled Surface Morphology

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Recently, as the importance of eco-friendly energy has emerged, studies on CO2 capture, which is a conventional chemical reaction, particularly CO2 conversion into fuel, are being actively conducted. In this study, in order to increase the performance of the heterogeneous noble metal (Ru, Rh) catalyst used for CO2 methanation, a core-shell microstructure with aluminum core was introduced as a support, and the reaction activity change according to the morphology of the surface was observed. The Al@Al2O3 microstructure was prepared by hydrothermal reaction of aluminum metal or solvothermal reaction of NH4Cl and MgCl2 solution, followed by calcination, and has surfaces in the form of 3D nanocuboid, 2D nanoplate, and 1D nanorod, respectively. Since the controlled surface exhibits different acid properties depending on the exposed crystal plane [1], it exhibits different interactions with the active metal phase [2]. 1wt% Ru and Rh noble metal phases, used in the CO2 methanation (CO2 + 4H2 -> CH4 + H2O) reaction, impregnated on this Al@Al2O3 microstructures, and compared the metal-support interaction by identifying the CO2 conversion and selectivity.

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바이오가스 수증기 개질 반응 조건의 최적화를 위한 열역학적 평형 분석 및 촉매 반응 실험

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Thermodynamic Equilibrium Analysis and Catalytic Reaction for the Optimization of Reaction Condition in the Steam Reforming of Biogas

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본 연구에서는 열역학적 평형계산을 통해 바이오가스 수증기 개질 반응에 대한 특성을 연구하였다. 열역학적 평형 계산을 위해 HSC Chemistry 소프트웨어를 사용하였다. 최적 반응 조건 선정을 위해 투입 수증기량, 전환율, 수율, 탄소침적을 고려하였다. 산화제/메탄의 비 ((H2O+CO2)/CH4 = 1.0 ~ 1.6)와 온도 (500 ~ 1000 oC)를 변수로 선정하였고, CH4, CO2 및 H2O 전환율, H2, CO 및 탄소침적 수율, 생산된 합성가스의 H2/CO 비를 계산하였다. 열역학적 분석 결과에 따르면, H2O/(CO2 + CH4) 비는 바이오가스의 수증기 개질 반응에서 CH4 전환율, CO2 전환율, H2 수율, CO 수율, 탄소침적 및 H2/CO 비에 중요한 영향을 미치는 것을 확인하였다.

도장시설에서 배출되는 탄화수소로부터 수소 생산을 위한 열역학적 평형 계산

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Thermodynamic Equilibrium Analysis for Hydrogen Production from Hydrocarbons emitted from Painting Facilities

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본 연구에서는 열역학적 평형 계산을 통해 도장시설에서 배출되는 탄화수소로부터 수소 생산에 관해 연구하였다. 도장시설에 배출되는 탄화수소 중 알케인계 탄화수소(메테인(CH4), 에테인(C2H6), 프로페인(C3H8), 부테인(C4H10))를 선정하였다. 열역학적 평형 계산은 Gibbs 자유에너지 최소화 기법을 이용하여 계산하였다. H2O/C비(1.0~3.0)와 반응 온도(500~1000 oC)를 변수로 하여, 이론적 전환율, H2 및 CO 수율, 탄소침적 및 H2/CO 비 생성량 계산하였다. 최적 반응 조건 선정을 위해 투입 수증기량, 전환율, 수율, 탄소침적(부반응)를 고려하였다. 열역학적 분석 결과에 따르면, CH4을 제외한 C2H6, C3H8, C4H10는 모든 온도에서 100%의 전환율을 나타내었으며, 이는 과량의 수증기량과 상관없이 나타난 결과이다. H2 수율은 온도가 증가함에 증가하였으나, H2O/C비=2.0 및 3.0일 때, 각각 700 oC 및 650 oC 이상의 온도에서 역수성가스전환 (Reverse water gas shift) 반응 발생에 의해 H2 수율이 감소하였다. 탄소침적은 온도 및 H2O/C비가 증가함에 따라 탄소침적 형성량이 감소하였다. 특히, H2O/C 비가 2.0 와 3.0일 때 모든 온도에서 탄소침적이 일어나지 않는 것을 확인하였다.

Preparation and Release Properties of Functional Acetaminophen Loaded MBS/PVA based Biomaterials for Transdermal Drug Delivery

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This study focuses on the synthesis of functional acetaminophen (AP) loaded biomaterials for a transdermal drug delivery using mung bean starch (MBS), polyvinyl alcohol (PVA), sodium benzoate (SB) as a crosslinking agent, glycerol (GL) as a plasticizer, and melanin (MEL) as a photothermal agent. The prepared AP loaded biomaterials were characterized and evaluated for FE-SEM and physical properties such as tensile strength (TS), elongation at break (%E), solubility (S), and swelling behavior (SB). The photothermal effect and AP release properties for functional biomaterials were examined with the irradiation of 808 nm NIR laser (1.5 W/cm2). When the 808 nm NIR laser was irradiated on functional biomaterials with/without the addition of MEL for 21 min, the temperature of MEL non-added biomaterial was increase to 26 °C from 29 °C. However, MEL added biomaterial was increase to 26 °C from 40 °C. Results indicate that there is the photothermal effect of prepared biomaterial with the addition of MEL. Based on the results, the AP release properties was performed using standard buffer solutions and artificial skin. The results could be verified that AP release rates of MEL added AP loaded biomaterials were 1.2 times faster than that of MEL non-added AP loaded biomaterials by the irradiation of NIR laser for 21 min. From the results, we suggest that functional biomaterials can be applied as a biomadical material for acute pain-killing treatment.

Keywords

Transdermal drug delivery biomaterial, Melanin, Photothermal effect, Acetaminophen, Release properties

팔라듐계 분리막 반응기를 사용하여 암모니아 분해반응을 통한 수소생산에 관한 연구

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Hydrogen production from ammonia decomposition using Pd-based membrane reactor

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전 세계적으로 화학연료의 지속적인 사용으로 인해 CO2 배출 가스가 늘어 이를 대체할 신재생 에너지 중 하나인 수소가 미래를 책임질 에너지원으로 대두되고 있다. 우리나라의 국가적 장기 프로젝트를 봤을 때 2040년까지 수소공급량을 최대 연 526만 톤까지 늘릴 계획이며, 그 중에서 가격 경쟁률을 고려하여 값 싼 암모니아를 활용하여 그린수소를 도입할 생각이다. 암모니아 전 세계 생산량은 연간 약 2억톤에 달하며 인구수의 증감추이와 비례하여 증가하고 있다. 우리나라는 암모니아 대표 수입국으로서 연 140만톤의 암모니아를 수입하고 암모니아는 화학물의 원료, 비료 등 다양한 산업분야에서 사용되고 있다.

암모니아는 액화가 쉽고 저장 용량도 높을 뿐만 아니라 운반도 용이하다. 암모니아 분해는 수소를 생산하는 공정에서 높은 수소 회수율을 가질 뿐만 아니라 암모니아에서 다시 수소를 추출하는 것이 어렵지 않다. 수소 생산 시스템 구성이 용이한 팔라듐 복합 분리막 기반 암모니아 분해는 공정을 통해 암모니아를 통하여 수소를 생산하는 연구를 진행하였다. 분리막 반응기용 수소 분리막은 직경 1/2인치, 길이 45cm인 Inconel 600소재의 튜브형 다공성 금속 지지체 위에 blowing coating method로 세라믹 확산방지층을 코팅하고, 그 위에 electroless plating을 통해 팔라듐 복합 분리막을 제조하였다. 제조된 팔라듐 분리막은 루테늄 촉매와 함께 튜브형 반응기를 구성하여 암모니아 분해 반응을 진행하였다. 암모니아 분해 반응은 공간속도 852 h−1, 반응온도를 472℃, 분리막 양단간의 압력차이 5 bar로 유지하였다. Bubble flow meter를 통해 permeation stream 유량과 총 유량을 을 측정하였고, gas chromatography를 통해 permeation stream 조성을 분석하였으며, retentate stream 암모니아 농도는 검지관을 사용하여 측정하였다. 실험결과, 총 유량 및 retentate stream 암모니아농도 분석결과로 계산된 암모니아 전환율은 99.9% 이상이었으며, 분리막을 투과한 수소농도는 99.95%이었고, 발생한 수소대비 약 99%가 분리막을 통하여 분리된 것을 확인하였다. 암모니아 분해반응이 있어 팔라듐 복합 분리막 반응기는 탄소배출을 최소화 하면서 수소를 생산할 수 있는 에너지 절감형 그린수소 생산기술로서 적합함을 확인하였다.

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Keywords 팔라듐 복합 분리막, 암모니아, 암모니아 분해, 그린 수소, 탄소배출

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Synergistic effects of supercritical CO2 and activated carbon catalysts on the hydrolysis of cellulose to glucose

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Cellulose is a renewable chemical feedstock that can replace petroleum oils. The depolymerized derivatives of cellulose such as glucose and furans are attractive green monomers for the synthesis of plastics, surfactants, high-octane number gasoline, diesel fuels and medicines. In this respect, various kinds of heterogeneous catalysts, including sulfonated carbons, sulfonated silica, zeolites have been studied for the efficient hydrolysis of cellulose to the targeted monomers such as glucose [1]. However, the conversion of cellulose to glucose is highly limited due to its high crystallinity induced by a large number of intramolecular and intermolecular hydrogen bonds in cellulose structure and low solubility to water solvent. The ball-milling of cellulose was reported to effectively decrease the cellulose crystallinity and increase the water solubility, thereby enhancing its hydrolysis rate significantly. So far, the use of sulfonated carbon catalysts with the pretreatment of cellulose with ball-milling achieved the highest glucose yield of as high as ~75%. Among many catalyst system, sulfonated activated carbon catalysts have shown to be highly effective for the hydrolysis of cellulose because abundant surface hydroxyl groups act as the adsorption sites of cellulose while the sulfonic acid groups anchored by the sulfonation treatment well catalyze the cleavage of the β-1,4-glycosidic bonds of cellulose. However, the extremely harsh ball-milling conditions (300 rpm, > 48 hrs) and long reaction time (> 24 hrs) are still required to obtain the high glucose yield (> 60%), decreasing the process efficiency. In this study, we investigate the effect of supercritical carbon dioxide on the hydrolysis of cellulose over sulfonated carbon catalyst as an additional source of acidity. We demonstrate the enhanced hydrolysis rate of cellulose by the combination of supercritical CO2 and activated carbon catalysts by a series of kinetic experiments.

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One-step 수열합성한 Ni@Ni3S2 전극을 이용한 슈퍼커패시터의 전기화학적 특성

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Electrochemical properties of supercapacitors using one-step hydrothermal synthesized Ni@Ni3S2 electrodes

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슈퍼커패시터는 리튬이차전지에 비해 10배이상의 고출력특성(~10kW/kg)과 빠른 충방전속도 및 긴 사이클수명으로 많은 관심을 받아왔으며, 탄소기반 소재를 사용함으로써 리튬이차전지에 비해 저렴하고 가벼운 장점이 있다. 하지만 슈퍼커패시터는 에너지밀도가 5-10Wh/kg로 낮아 에너지밀도 향상을 위한 연구가 지속적으로 진행되어 왔다 [1,2]. 슈퍼커패시터의 낮은 에너지밀도를 향상시키기 위하여 질화물, 인화물, 황화물에 대한 연구가 진행되고 있으며, 특히 전이금속 황화물은 산화물에 비해 전기전도도가 우수하고 전기화학적 활성도가 높아 우수한 산화-환원 가역성을 나타내며, 기계적/열적 안정성, 높은 정전용량, 저비용 등과 같은 장점을 가지고 있다. 그중 황화니켈은 현재까지 금속염(nickel acetate, nickel nitrate, nickel chloride)과 황산나트륨(SS, sodium sulfate), 티오아세트아미드(TAA, thioacetamide), 티오우레아(TU, thiourea) 및 티오황산나트륨(STS, sodium thiosulfate) 황전구체를 사용하여 다양한 형태를 제조하여 왔다. TU를 이용하여 제조한 Ni3S2는 10 mA/cm2의 전류밀도에서 1293 F/g(1000 사이클 기준 78.5%의 유지율), TAA를 이용한 것은 1.342 F/cm2 (15 mA/cm2)의 정전용량을 보였다 [3,4]. 본 연구에서는 Ni3S2를 간단한 수열합성방법을 통하여 제조하고 재료 및 공정비용을 절약하고자 저가의 황분말과 KOH를 이용하여 Ni3S2를 제조하여 전고체 슈퍼커패시터에 응용하였다. 그 결과, 10 mA/cm2의 전류밀도에서 2111 F/g (24.1 F/cm2)의 높은 비정전용량을 나타내었고 20 mA/cm2의 전류밀도에서 충방전 시 약 86%의 용량 유지율을 나타내었다.

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In-situ FT-IR analysis for dehydration of lactic acid on KBr-exchanged zeolites

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Lactic acid (LA) derived from biomass is a potential green feedstock to produce acrylic acid (AA) which is a versatile monomer in petrochemical industry. As LA is easily produced through fermentation of saccharides, the dehydration of LA to AA can be an alternative route to the current propylene oxidation process. Prior study showed that high selectivity of AA is possible with alkali-exchanged zeolites with the proper strength of acid and base sites. Specifically, Bo Yan et al. showed that dehydration selectivity of LA can reach as high as ~80% on KBr-exchanged Beta and MFI [1]. However, the reason behind the enhanced selectivity, especially from the mechanistic point of view, is not well understood. Therefore, our study aims to reveal the dehydration mechanism of LA on high-selectivity KBr-exchanged ZSM-5 through in-situ FT-IR by comparison with low-selectivity Na- and KNO3-exchanged ZSM-5. We find that the proton of carboxyl group in LA is ion-exchanged with potassium/sodium cation of zeolite as the first step of the reaction, forming potassium lactate. Importantly, the degree of ion exchange is directly correlated with AA selectivity, i.e., the higher the formation of lactate, the higher AA selectivity. Then, the in-situ generated BrØnsted acid sites on zeolites act as the active sites for the dehydration of lactate to acrylate. The final step is the reverse ion exchange of potassium cation of acrylate with the proton of zeolites, forming acrylic acid. On KBr-exchanged zeolites, the IR peak of acrylate completely disappeared at 200°C, which is much lower than those of other catalysts, suggesting that the dehydration is very facile over the highly selective catalyst. The detailed characterization of the catalysts revealed that the Br anion deposited on zeolite surface impact the acidity and basicity of K-ZSM-5 greatly, providing the further insight into the link between the zeolite acidity/basicity and AA selectivity.

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다시마 유래 액화액의 수증기 개질반응을 통한 수소생산을 위한 Ni/Mg/Al-LDHs 유래 혼합산화물 촉매의 반응특성

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Reaction Properties of Ni/Mg/Al LDHs–like Catalysts for Hydrogen Production of S. japonica-derived Liquefied oil by Steam Reforming

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친환경 연료유인 수소는 현재 다양한 방법으로 생산되고 있으며, 보통 화석연료의 개질 반응을 통하여 생산된다. 하지만 화석 연료는 한정된 량과 수소를 생성하는 과정에서 온실가스 배출이라는 단점을 갖고 있어, 이를 대체하기 위한 다양한 바이오매스로부터 수소생산을 위해 지속적인 연구가 진행되고 있다. 본 연구에서는 3세대 바이오매스로 해조류의 한 종류인 다시마의 액화액으로부터 수증기 개질반응을 통한 수소생산을 위해 이중층 수산화물 구조체 기반 Ni/Mg/Al 혼합산화물촉매를 적용하여 촉매의 반응특성을 평가하고자 한다. 본 실험은 고정층 반응기에 Ni1.5Mg1.5Al1.0 촉매를 장착하여 S/C의 비가 10.5인 다시마 액화액을 반응온도는 400~900, 공간속도는 0.5~3.0 h−1범위로 하여 반응표면분석법을 통하여 수소생산에 최적의 반응조건을 확인 하였다. 실험결과, 750, 1.0 h−1 조건에서 수소수율이 약 86%, 탄소전환율이 약 93%로 가장 높은 효율을 보였으며, Mg3.0Al1.0 지지체 표면에 Ni 13 wt%를 담지한 촉매는 약 70%의 수소 수율을 보였다. 이는 이중층 수산화물 구조체를 기반으로 제조된 Ni1.5Mg1.5Al1.0 촉매의 활성 금속인 Ni이 표면에 고르게 분산 되어 촉매의 활성이 증가한 것으로 판단되며, 반응 후 촉매 표면에 탄소 침적량을 확인한 결과 약 3%의 탄소 침적이 생성된 것으로 보이며 이는 Mg 성분으로 인해 탄소 침적 생성을 억제한 것으로 보인다.

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Effective big data processing strategy for low-cost sensor-based dust monitoring

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A dust monitoring and modeling system with low-cost sensors and a standard air dispersion model should be effective for cost efficiency and facilitation of utilization. However, this can be problematic sometimes because of poor reliability of the low-cost sensor measurement and the simplified model performances as well as requirement of handling a big dataset from the sensor monitoring and the modeling. Therefore, this study suggests a big data processing strategy, specifically in order for a mine dust monitoring with low-cost sensors and a standard air dispersion model such as AERMOD. The big data processing system for this study should address three categories of the issues; (1) calibration & validation (2) automatic fault detection (3) key data summarization. In addition, this study would discuss the various big data processing techniques to resolve the tasks above, from the simple linear regression to the artificial neural network algorithm.

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Installation of a mine dust monitoring network using low cost sensors

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Dispersion of airborne dusts emitted from mine sites threatens regional environments and human health and therefore requires a proper dust monitoring system. However, installation and operation of the monitoring system of dust dispersion is typically a cost-consuming task because the system requires multiple stations with expensive airborne dust sensors. Alternatively, it is recommended to use of low cost sensors that can be adopted as a practical option if the resultant monitoring quality is reliable. Therefore, this study proposes a low-cost dust sensor network to be installed to monitor the dispersion of airborne dusts from open pit limestone mines. The monitoring system is successfully installed with remote telecommunication with LTE (Long Term Evolution) and TCP/IP (Transmission Control Protocol/Internet Protocol) basis as well as multiple low cost dust sensors equipped in individual monitoring stations.

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Air quality modeling strategy for mine dust dispersion

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Mine dusts generated from various mining activities give harmful effects to environments and human health. Therefore, a proper air quality management focusing on mine dust dispersion is often required with understanding of its physical mechanisms and relevant prediction. To resolve this issue, a modeling approach with air dispersion model is desirable to be applied to quantify the mechanisms and predict spatiotemporal distribution of mine dust in dispersion. In addition, the model data should be properly calibrated and validated by the measured dataset. Therefore, this study would propose an air quality model strategy for the prediction of mine dust dispersion. Especially, reliability of the model prediction and modeling of particle size effects in various phenomena on mine dusts such as deposition, turbulent diffusivity, wind erosion, and agglomeration are emphasized.

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Pt/Al2O3 촉매의 Sn, K 첨가에 따른 프로판 탈수소 반응에 미치는 영향

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고분자 재료 중 프로펜의 가치가 높아지면서 최근 프로펜의 수율을 높이기 위한 연구를 진행하고 있다. 프로펜이 부산물로 나오는 공법들은 에틸렌과 같이 나오는 점이 특징이지만, 현재 에틸렌보다 프로펜 사용에 대한 성장률이 평균적으로 에틸렌보다 높은 것을 감안하면 프로펜을 부산물로 하는 공법보다는 주 생산물로 하는 공법에 대한 연구가 더 필요하다. 본 연구에서는 프로펜을 주 생산물로 하는 공법 중 프로판 탈수소화 반응에 대한 연구를 진행하였다. 프로판 탈수소화 반응에 의한 프로펜 전환율을 높이기 위하여 촉매의 조성, 반응물 유량, 반응 온도를 변경하여 연구를 진행하였다. 이 때 K의 전구체로는 K2SO4를 사용하여 촉매를 제조하였다. 특성분석으로는 XRD, CO-chemisorption, TPR분석을 통해 활성 금속의 분산도를 확인하였다. 모든 반응 조건에서 Pt-Sn 촉매가 가장 높은 전환율과 수율을 얻는 것을 확인하였다.

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Should We use Argon Isotherms to Analyze the Surface Area of Nanoporous Materials?

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Surface area is one of the most important physical properties of porous material. Generally, surface areas are determined from a nitrogen adsorption isotherm using the Brunauer–Emmett–Teller (BET) method. However, a recent IUPAC report recommends using an argon adsorption isotherm instead of the nitrogen adsorption isotherm to compute the BET surface area due to the purported "orientational" effect [1]. However, the magnitude of such effect has not been fully characterized in the literature, making it difficult for the community to accept the new standard for porous materials characterization. In this study, we carried out large-scale molecular simulations to investigate the orientational effect of nitrogen and its impact on accurately determining the surface area. Molecular simulation results show that the monolayer coverage (obtained directly from the BET analysis) of a material significantly differs between nitrogen and argon adsorption isotherms. Additional analyses from the molecular simulation snapshots suggest that the discrepancies originate from the inefficient packing of nitrogen molecules compared to argon molecules on the surface.

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The Catalytic activity of Mn based catalysts coated on metallic monolith for low-temperature SCR of NOx with NH3

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The selective catalytic reduction (SCR) of NOx with NH3 is the major technology to reduce nitrogen oxide emissions from stationary sources. The commercial SCR catalyst focused on the V-W based ceramic honeycomb catalyst, which has several disadvantage such as high reaction temperature (300-400oC), poor sulfur resistance and price. For these problems, many researchers have reported the Mn-containing catalyst with high efficient activity in low-temperature NH3-SCR. In this study, the Mn-based low-temperature (L-T) SCR catalysts coated on the metallic monolith were prepared by dip-coating method. The catalyst coated on the SUS-based substrate was prepared by dip coating techniques using slurry wash coating method. The metallic monolith catalyst was fabricated with strong adhesion by coating, drying, and calcination process. The catalytic performance of Mn based L-T SCR catalysts were tested with/without the SO2 species at 220 oC. The Fe promoted Mn based catalyst showed enhanced NOx conversion and SO2 tolerance, suppressing the formation of ammonium bisulfate.

Keyword

Low temperature SCR, de-NOx, metallic monolith, slurry coating, dip-coating

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배가스 전처리 공정 구축을 위한 사이클론 집진장치의 전산입자유동 해석

서준형, 김영진, 조계홍, 조진상 한국석회석신소재연구소

Computation particle flow analysis of cyclone dust collector for establishment of exhaust gas pretreatment process

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시멘트 산업에서 질소산화물을 저감하는 기술 중 가장 많이 사용되고 있는 공정은 선택적무촉매환원법(SNCR)이지만 제거효율이 50% 내외로 낮아 향후 정부에서 강화하는 배출허용기준을 만족시키기에는 어려울 것으로 예상되기 때문에 선택적촉매환원법(SCR) 등의 추가적인 장비 개선 및 기술 확보가 필요한 상황이다. 이에 본 연구에서는 시멘트 산업 내 SCR 적용을 위한 배가스 전처리 공정 구축과 관련하여 사이클론 형태별 분진 포집 효율에 대한 전산입자 유동 해석을 수행하고 적용 가능성에 대해 분석하였다. 분석 결과 병렬형 사이클론이 단일형 사이클론에 비해 분진 포집 효율이 우수한 것을 확인할 수 있었으나 병렬형 사이클론의 경우 공간적인 문제가 추가적으로 발생되기 때문에 추후 이 부분을 고려하여 설계에 반영하는 것이 필요할 것으로 판단된다.

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e포스터

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청정융합

Efficient Oil-Spill Remediation via Solar-driven Evaporation Combined with Adsorption by Carbonized Photothermal Fabric

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The conventional remedy to remove the spill-oil on water is performed by adsorption using known inorganic (vermiculite, carbon material, sepiolites, and zeolites) and organic (natural fibers-based, such as cotton fibers, corn stalk, and non-woven wool) sorbents. Along with the high adsorption capacity (3-80 g g-1) and good regeneration ability, the inorganic ones have poor buoyancy causing the sinking of the adsorbent. The organic sorbents despite the low price, eco-friendly properties, and fast removal of oil through the pore-filling mechanism are limited in capacity due to a small pore volume. Thus, the development of novel materials and technologies for fast and efficient oil-spill remediation is needed.

Here, we propose a new concept for oil-spill remediation, based on solar-driven evaporation of oil combined with adsorption (SEOA). In this method, the light crude components are evaporated by photothermal heating, and the heavy components are adsorbed in the adsorbent. We designed photothermal adsorbent, by carbonizing pristine non-woven fabrics through relatively low-temperature thermal treatment, providing low cost, highly efficient, and ecofriendly SEOA. Solar-driven evaporation was accelerated more than 3 times, enabling the fast removal of a light fraction of crude oil (~70%). Moreover, the highest oil removal capacity (110 g g-1) was achieved among ever-reported oil-adsorbents through the combination of solar-driven evaporation of light oil components and adsorption of the remaining oil.

수용성 마이크로 니들 제조

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Preparation of water soluble micro needles

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기존의 약물 전달 방법은 체내에 직접적으로 약물을 주사하는 피하 주사 방법과 먹어서 약물을 전달하는 경구 투여 방식이 있다. 이들 방법은 극심한 고통 유발하거나 소화 과정에서 예상치 못한 부작용을 낳을 수 있는 단점을 가지고 있다. 이러한 단점을 보완하기 위해 경피 약물 전달 시스템 (TDDS)에 대한 연구가 활발히 진행되고 있다. 생체 적합성이 뛰어난 수용성 고분자를 침상 형태로 제조하여 피부에 붙이거나 문지르면 피부를 투과 한 후 체액에 용융되어 고통이나 부작용 없이 효율적인 방법으로 약물을 체내에 전달할 수 있다.

본 연구에서는 히알루론산(HA)를 주원료로 사용하여 마이크로 니들을 제조하였다. HA는 피부 보습과 상처 재생에 효과가 있으면서 부작용이 적어 화장품 재료로 많이 사용되고 있다. HA를 증류수에 용해시킨 후 음각된 PP 몰드에 이를 도포한 후 건조시킨 후 몰드에서 분리시켜 200 – 400 ㎛ 크기로 마이크로 니들을 제조하였다. 친수성이 큰 HA와 소수성이 큰 PP 몰드의 표면장력과 탈부착 문제를 해결하기 위하여 여러 가지 혼합물을 첨가하여 이들이 니들의 형태와 강도에 미치는 영향을 고찰하였다. 또한 용액에서 기포를 제거하기 위하여 여러 가지 전처리 방법을 시도하였다. 니들의 제조에 영향을 미치는 요인으로서는 전처리 방법, HA와 증류수의 질량비, 건조온도, 그리고 첨가물의 종류와 농도 등을 고려하였다. 최종 생성물의 형태와 크기는 SEM과 광학현미경을 통하여 확인하였고 기공률과 혼합용액의 표면장력은 각각 Mercury Porosimeter와 Sulface Tension Tester로 측정하였다.

Enhanced bioelectricity generation by PDA/PPY-CF modification for high performance anode in microbial fuel cell

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Microbial fuel cells (MFCs) convert chemical energy directly to electrical energy via electrochemically active microorganisms. Such bacteria exchange respiratory electron with electrode via extracellular electron transfer (EET) through biofilm matrix. Therefore, the interaction between microbes and electrode surface is a key factor to increase power density of MFC. In this study, a novel polydopamine(PDA)/polypyrrole(PPY) modified carbon felt by a facile electrodeposition method for an improved MFC performance. The MFC equipped with PDA-PPY-CF anode presented 500 mW/m2, which was 1.5, 1.15, and 1.13 times greater than those of the unmodified carbon felt (CF), PDA-CF, PPY-CF, respectively. PDA has superior hydrophilicity and adhesive force for biofilm development, while PPY provides electrochemically active sites for electron transfer between biofilm and anode. Results from Raman spectroscopy, Brunauer-Emmett-Teller (BET) and Contact angle analysis show increase in the physicochemical properties of PDA/PPY-CF. Furthermore, the electrochemical analysis on the modified anode confirmed the bioelectrochemical activity and reduced electrochemical impedance. These results show that modification with PDA/PPY provides excellent electrochemical properties for electrochemically active biofilm for MFC, therefore enhance performance MFC for bioelectricity generation and bioconversion.

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Carbon felt electrode for Electrochemical detection and removal of endocrine disruptor, bisphenol A

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2,2-Bis (4-hydroxyphenyl) propane (bisphenol A) is a precursor in many industrial and manufactural resins, plastics, and polycarbonate, as well as an endocrine disruptor in humans and animals. Hence, the real-time sensing and in-situ removal of BPA are in strong demand. Here, this study evaluated a method for the electrochemical detection of BPA using a carbon felt electrode. BPA was detected by cyclic voltammetry. During detection, the BPA was electropolymerized to a non-conductive lump and layer on the electrode surface. Simultaneously, the capacitance and electrochemical properties of the carbon felt decreased. The peak current and BPA concentration showed a linear correlation, and the estimated detection limit was 4.78 × 10-7M. The BPA electropolymerized carbon felt could be regenerated successfully by ultrasonication. The detection and quantification of BPA in real water samples showed satisfactory recoveries of 98.4 - 101.0%. The carbon felt exhibited high sensitivity and reusable, excellent performance in detection of BPA in real water samples, which expect that carbon felt-based electrochemical analysis is applicable development of in-situ and on-site detection and removal of endocrine disruptors as well as BPA.

Dynamic box method of aquifer injection to improve particle transfer effect

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The utilization of in-situ remediation methods is increasing as it offers a number of economic and environmental advantages [1]. However, the injection of inadequate materials for the contact with target contaminant or the short contact/retention time to react with the target materials due to heterogeneity of subsurface make the conventional methods inefficient [2]. In this study, we tried to increase the retention time of the treatment materials in the aquifer through dynamic box methods to resolve the channeling effect. The box has a volume of 0.12 m3 with a water-saturated zone containing intersection of sand and clay layers. Tracer tests were performed by pulse-feeding the salt solution in different depth of the box at different cycles (0.5 and 1 hour) to analyze the concentration of the tracer materials, particle delivery time, and geophysical characteristics. A control experiment was also performed to compare the performance of dynamic box method. Variation on the injection depths did not change the tracer materials' arrival time, which usually varies in the conventional method due to the channeling effect. When pulse-fed, the retention time was increased significantly which indicates improved degree of particle delivery. Thus, the dynamic injection method could improve the remediation efficiency by increasing the interaction between the particles and soil when a material is injected for subsurface remediation.

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The effect of Aluminum Oxide Nanoparticle on freshwater microalga, Scenedesmus obliquus

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Nanoparticles are inevitable by-products of modern industry. Despite their various applicability, it poses severe environmental and human health hazards, such as cell membrane disruption, neurodegenerative disorder, and water treatment processes disruption. Also, it may cause negative influences on the wastewater treatment process by interfering with the degradation and removal of emerging contaminants by microbial agents. In this study, we investigated the comprehensive effect of aluminum oxide nanoparticles (Al2O3NP) on a green microalga, Scenedesmus obliquus, and their effects on the removal of an emerging contaminant, sulfacetamide. The effects induced by Al2O3NP were analyzed by several bio-physiological aspects: growth inhibition, changes in biochemical components, gene expression, and biodegradation capacity for sulfacetamide. The result shows that microalgal growth only impacted at higher concentrations (≥50 mg L-1) of Al2O3NP where dry cell weight and pigments of S. obliquus were significantly inhibited. After 14 days of cultivation, up to 15% of growth inhibition and 23% of chlorophyll concentration reduction of S. obliquus was observed at 100 mg L-1 of Al2O3NP with 1 mg L-1 sulfacetamide. The gene expression of five functional genes (psbA, ATPF0C, Lhcb1, and HydA) that are related to photosynthetic system of freshwater microalgae were downregulated up to 69.99, 66.32, 47.37, and 64.89%, respectively, and the expression level of Tas was upregulated up to 369.45% in the presence of Al2O3NP. Although there was the insignificant influence of Al2O3NP on the removal of sulfacetamide, 8% and 12% removal of sulfacetamide was observed at 50 mg L-1 of Al2O3NP with 1 mg L-1 and 15 mg L-1 of sulfacetamide, compared with 13% and 17% removal in the control. The exploration of this study has provided a deeper understanding of the environmental effects of Al2O3NP and confirm the potential of microalgae mediated water treatment system under nanoparticle induced stress.

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Standardization of surfactant mediated washing of contaminated soil

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Surfactant mediated soil washing is one of the most effective methods for remediation of diesel contaminated soil [1]. Tween 80 (Polysorbate 80) is believed to be most efficient surfactant for soil washing, globally [2]. However, micelles formed by surfactant and diesel are adsorbed on soil particles, resulting in the reduction of diesel removal rate [3]. In this study, a batch experiment was performed to determine the optimum condition for efficient removal of diesel from the contaminated soil using different concentrations of Tween 80 (0%, 0.01%, 0.1%, 0.5%, 1%, and 1.5%, v/v) at different pH values (4, 5.5, 7, 8.5, and 10) and applied to varied clay ratios (0%, 5%, and 15%, w/w). In absence of clay (0%), the washing efficiencies in all pH were around 73–76% for different Tween 80 concentrations, indicating higher diesel removal rate. The diesel removal rate of 71% was achieved using 1.5% Tween 80 at pH 10 with 15% clay, which was maximum among the experiments with clay. The analysis of GC-MS revealed that the removal patterns of different n-alkanes were similar and showed no preference under different conditions. These indicate that alkaline environment and sandy soil assisted the effective diesel removal from contaminated soil.

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Microbial upgrading of acetate into succinate by Pseudomonas putida

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Succinic acid offers great potentials as a platform chemical in bio-based plastics, solvents, adhesives, and resins. Succinate is an intermediate in TCA cycle and can be produced in reductive TCA pathway by fermentation. Hence, in this study, we attempted a novel bioconversion pathway for succinate production from acetate, which a fermentative byproduct and anoxic biodegradation of organic contaminants. An industrially applicable host strain, Pseudomonas putida was used as a biocatalyst. Various genetic engineering techniques were applied such as acetyl-CoA synthetase overexpression and succinate dehydrogenase deletion. This study provides a strategy to utilize the conventionally known refractory substrate such as acetate, and simultaneously produce succinate with novel pathway.

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CO2 electrosynthesis of polyhydroxybutyrate using Rhodobacter sphaeroides

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To alleviate the greenhouse effect and climate change, it is of great importance to develop sustainable CO2 capture and utilization. The microbial electrosynthesis (MES) has been highlighted to convert CO2 to value added metabolites and intermediate chemicals by using electrochemically active bacteria as biocatalyst and electricity as reducing power. However, the MES only produced simple organic acids or alcohols from CO2. In this study, we presented a novel bioelectrosynthetic pathway for polyhydroxybutyrate (PHB) production using a photosynthetic bacteria, Rhodobacter sphaeroides. The electrode attached R. sphaeroides directly uptakes electrons from the electrode surface, while the suspended Rhodobacter sphaeroides utilize the electrochemically evolved hydrogen as electron mediator to convert CO2 to polyhydroxybutyrate (PHB). The results show that MES-driven electrons and protons transfer enabled direct conversion of CO2 into higher-value added organic matter such as PHB.

Selective isolation of electroactive Pseudomonas strain using tungsten nanoparticle for enhanced bioelectricity generation in Biofuel cell

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Pseudomonas sp. has been known to have diverse capability of feedstock conversion and bioremediation for recalcitrant organic contaminants, thus extensively studied for its metabolic pathway and recombination purposes. Recently, Pseudomonas sp. has been highlighted for production of valuable commodity, bioremediation, biosensor and wastewater treatment, therefore many Pseudomonas strains have been screened by various isolation strategies. Some Pseudomonas sp. showed an electrochemical activity which transfer their respiratory electron to carbon electrode with simultaneous electricity generation in a microbial fuel cell. Bacterial cells carry out direct electron transfer by forming biofilm and/or indirect transfer via electron shuttle to deliver respiratory electron. In this study, we isolated a novel Pseudomonas strain using blue white screening method using tungsten nanoparticle. The enrichment stage used a designed growth media to pose selective pressure for growth of Pseudomonas from mixed inoculum. Pseudomonas aeruginosa sp.(HK07) was isolated and was tested for electrochemical and bioconversion activity (Poster).

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수중 BTEX 독성탐지를 위한 kit형태의 황산화미생물 생태독성평가법 개발

김승규, 엄헌섭, 오상은
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Development of ecotoxicity assessment using kit-type sulfur-oxidizing bacteria (SOB) for detection of BTEX toxicity in water

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독성오염물질 발생은 생태계 파괴의 주요한 원인이다. 이러한 독성오염물질을 검출하는 방법에는 가스크로마토그래피(GC), 액체크로마토그래피(LC) 등의 방법이 있지만, 고가의 장비와 기기분석에 숙련된 인력이 필요하며 독성오염물질에 따라 분석 방법이 다른 경우 제한된 시료 내 모든 독성물질을 검출할 수 없다는 단점이 존재한다. 특히, BTEX(Benzene, Toluene, Ethylbenzene, Xylene)의 경우 물에 대한 용해도가 낮고 휘발성이 타 물질들에 비해 매우 높기 때문에 시료채취부터 전처리 및 분석까지 허용되는 시간이 제한적이고 까다롭다. 그렇기 때문에 현장에서 간단하게 생물을 이용하여 독성도를 평가할 수 있는 생태독성평가 기법들이 다양하게 연구되고 있다. 황산화 미생물을 이용한 생태독성평가 기법은 미생물 배양과 시험적용이 간단하고 황산화미생물이 황을 산화시키면서 생성되는 황산이온(SO42−)을 전기전도도(EC)로 간편하게 측정 할 수 있는 장점이 있다. 또한, 황산화 미생물이 독성에 의해 활성이 저해 받을 때 줄어드는 황산이온 생성량과 그에 따른 전기전도도 감소로 독성을 평가하기 때문에 독성도를 수치화하여 정량하기 용이하다. 이러한 장점들을 바탕으로 BTEX 각 항목들의 개별독성을 평가하여 반수영향농도(Half maximal effective concentration, EC50) 값을 얻었고 p−xylene > ethylbenzene > toluene > benzene 순서로 강한 독성이 나타났다. 또한, 널리 이용되고 있는 조류 독성시험보다 BTEX 각 항목 별 반수영향농도가 낮게 도출되어 더 민감하고 정확한 BTEX 생태독성시험법으로써 활용 가능성을 확인하였다.

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Direct contact toxicity assessment of contaminated field soils based on the oxygen consumption activity of Sulfur - Oxidizing Bacteria (SOB)

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In this study, 11 uncontaminated and 9 contaminated field soils with varying geophysical and physicochemical characteristics were assessed for their toxicities based on the oxygen consumption activity of sulfur-oxidizing bacteria (SOB). Levels of oxygen consumption the reference soils were high and ranged between 7.9 mL and 9.5 mL while due to the presence of toxicants in the contaminated soils, oxygen consumption ranged between 0.4 to 5.4 mL. Inherent test variability (Cvi) values ranged between 1.22% and 3.88% while variation due to soil natural properties (Cvns) ranged between 3.52% and 16.9%. Determined Minimal Detectable Difference (MDD) values ranged between 2.12% to 4.25%. The determined toxicity threshold of 20% was established based on the computation of the Maximal Tolerable Inhibition (MTI). The levels of inhibition in the contaminated soils ranged between 42% and 100% above the 20% designated threshold. This observation makes all the contaminated soils toxic to SOB. A condition caused by elevated concentrations of heavy metal and organic contaminants. Notwithstanding the inhibitory effect induced by heavy metals and organic contaminants on SOB, increased proportions of clay and silt in test soils caused a reduction in oxygen by SOB. Overall, the oxygen consumption assay of SOB proved capable of evaluating the toxicity of contaminated field soils and was sensitive to heavy metals than organic contaminants. The procedure described in the herein is robust and suitable for the rapid toxicity assessment of contaminated field soils with the advantage of ease of handling, rapidity of testing compared to other procedures that employ the use of elutriates, and sophisticated equipment’s and tools.

Development of solid-phase bioassay using immobilized microalgae (Chlorella Vulgaris) to evaluate heavy metal-induced soil toxicity

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A method for a solid-phase soil toxicity test using immobilized microalgae Chlorella vulgaris was developed using soil spiked with heavy metals. Mostly, soil toxicity assessments are based on evaluating soil elutriates or extract toxicity or sand. Liquid-phase bioassays depend on the extraction of toxicants from a solid-phase using water or various organic solvents and subsequent exposure of aqueous eluents to test microorganisms. This approach cannot reveal contaminants' actual toxicity in solid-phase due to indirect interfacing between contaminants and microorganism. Microalgae is widely used in aquatic toxicity test, but it has rarely been employed in soil toxicity test because the soil particles make it difficult to count microalgae and block photosynthesis. In the case of free microalgae bioassay, it is challenging to separate microalgae from soil particles for endpoint measurement. Immobilized microalgae have the potential to overcome the difficulties encountered with free algae in solid-phase soil toxicity test. The present study was conducted with direct exposure of immobilized microalgae to soil spiked with mercury (Hg2+), silver (Ag+), copper (Cu2+), and cyanide (CN-) for 72 h in a 25 mL vial-based kit-type bioassay. Oxygen evolution in the gaseous phase as an indicator of photosynthetic activity in the bioassay were determined over 72 h exposure time. The toxicity of four selected heavy metals was assessed. Concentrations of 4.43, 4.18, 3.10, and 61.3 mg/kg were obtained as EC50 values for Hg2+, Ag+, Cu2+, and CN-, respectively, to inhibit oxygen evolution in microalgae (Chlorella vulgaris). Toxicities in decreasing order of strength were CN- > Ag+ > Hg2+ > Cu2+. Results obtained in the current studies demonstrate that immobilized microalgae bioassay is a suitable tool for evaluating the heavy metal-induced toxicity of the soil.

Physiological and electrochemical properties of a novel electrogenic bacterium enriched under high organic load in MFC

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The electroactive property in bacteria are been investigated extensively in recent times. The ecological, physiological and metabolic activity in such electroactive bacteria have been explored in bio-electrochemical cells. One such novel electrogenic bacteria was enriched under high organic load over a period of six months. Acclimatization of microbial consortia and metabolism of organic compounds in MFC were observed as increase in potential over time and reduction in COD, respectively. Isolation of pure culture was done by dilution plating method and isolated over 35 electroactive bacteria in MFC. 16S rDNA of isolates were collected, purified, amplified in PCR and sequencing of the transcriptome was done. The sequence was analyzed and phylogenetic identification studies were performed which revealed this bacterium as Kluyvera Georgiana. The physiological and genetic studies of this bacterium was studied in different conditions. The electroactive property of this bacterium was observed with its ability to produce over 200 mW m-2 of power density. Colonization and biofilm formation on the surface of electrode was observed under SEM. The expression levels of pili and flagella genes in this bacterium were found to be higher in MFC conditions compared to that grown in normal conditions. The pili genes were found to be expressed in higher amount in biofilm forming cells than in suspension cells. The present study has reported the physiological, metabolic and electrochemical properties of a novel electrogenic bacterium, Kluyvera Georgiana enriched in MFC.

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