Panel specjalizacyjny

KATALIZA PRZEMYSŁOWA I ADSORBENTY

Zakład Technologii Chemicznej



Kierownik Panelu:

prof. dr hab. Piotr Kuśtrowski
pokój D3-19
piotr.kustrowski@uj.edu.pl

UNIWERSYTET JAGIELLOŃSKI W KRAKOWIE

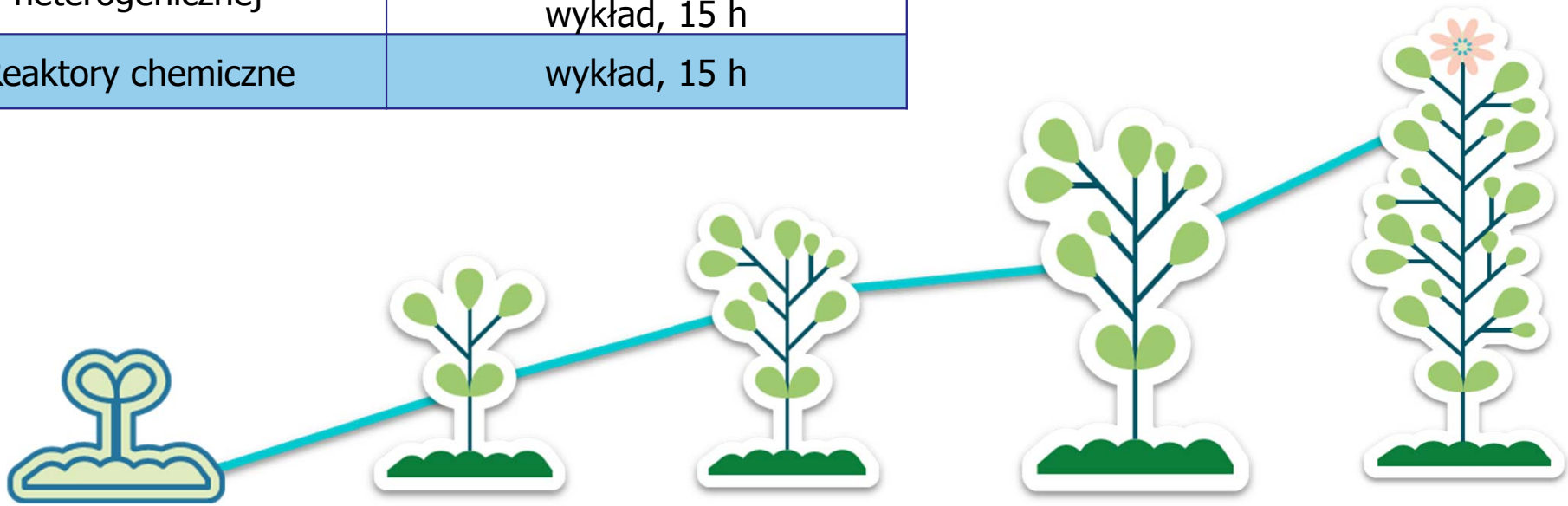
Założenia dydaktyczne panelu

Program dydaktyczny

Nazwa kursu	Forma zajęć
Kataliza przemysłowa	laboratorium, 90 h seminarium, 30 h wykład, 30 h
Metody charakteryzacji katalizatorów	laboratorium, 75 h seminarium, 15 h wykład, 15 h
Nowe materiały w katalizie heterogenicznej	laboratorium, 30 h seminarium, 15 h wykład, 15 h
Reaktory chemiczne	wykład, 15 h

Indywidualne mini-projekty badawcze

- samodzielna praca w formule "otwartego laboratorium"
- indywidualny opiekun naukowy
- aktualna tematyka badawcza
- przygotowanie do realizacji pracy magisterskiej

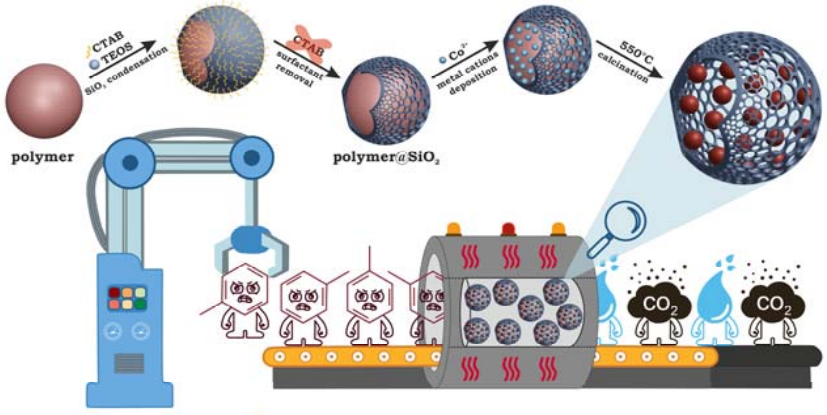


Koncepcja projektu | Synteza | Charakterystyka materiałów | Badania aplikacyjne | Publikacja

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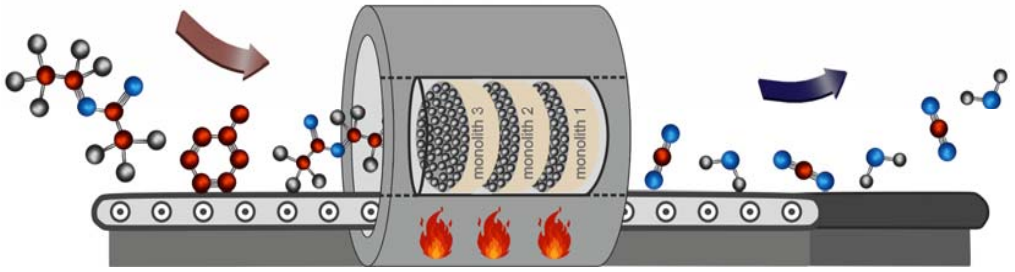
Tematyka prac dyplomowych

Usuwanie lotnych związków organicznych z atmosfery

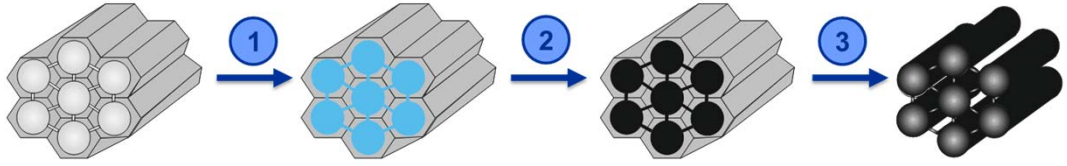


materiały rdzeniowo-powłokowe

monolity ceramiczne

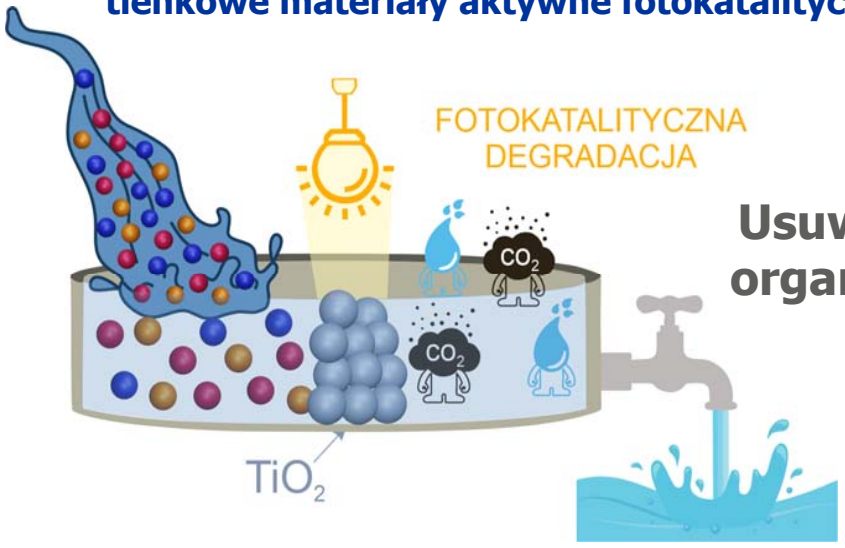


mezoporowate materiały węglowe



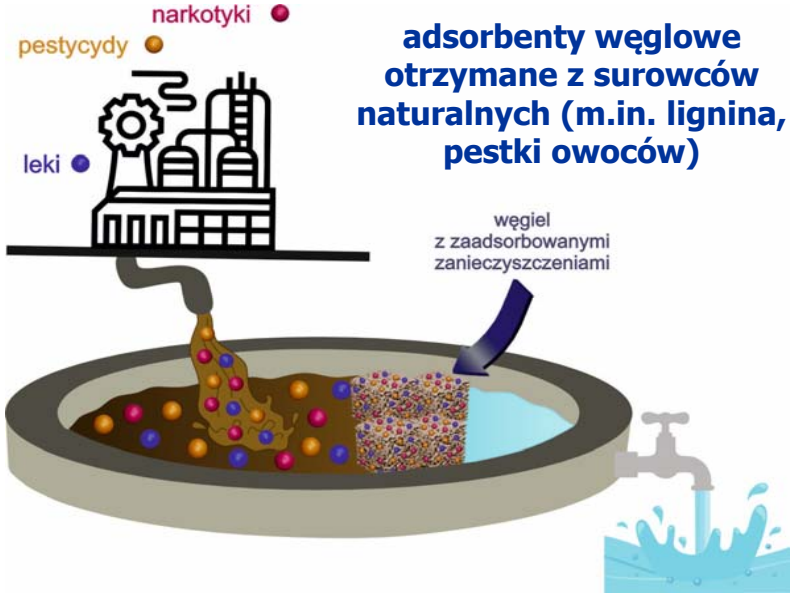
SBA-15 | kompozyt SBA-15-prekursor C | kompozyt C-SBA-15 | CMK-3

tlenkowe materiały aktywne fotokatalitycznie



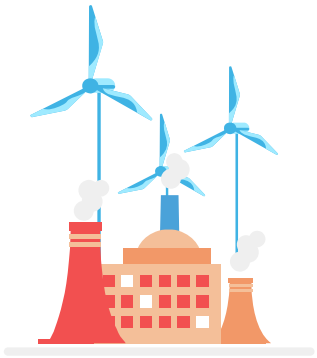
Usuwanie związków organicznych z wody

adsorbenty węglowe otrzymane z surowców naturalnych (m.in. lignina, pestki owoców)



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Tematyka prac dyplomowych



Zrównoważona produkcja paliw i farmaceutyków

- ekologiczne, utleniające odsiarczanie paliw
- utlenianie siarczków organicznych do produktów i półproduktów farmaceutycznych

Synteza odnawialnych źródeł energii

- synteza biopaliw i eteru dimetylowego z metanolu
- otrzymywanie wodoru na drodze rozkładu NH_3





Eliminacja zanieczyszczeń azotowych z powietrza

- redukcja NO_x (tzw. proces $DeNO_x$)
- rozkład N_2O
- utlenianie NH_3



Badania dotyczące mikroplastiku

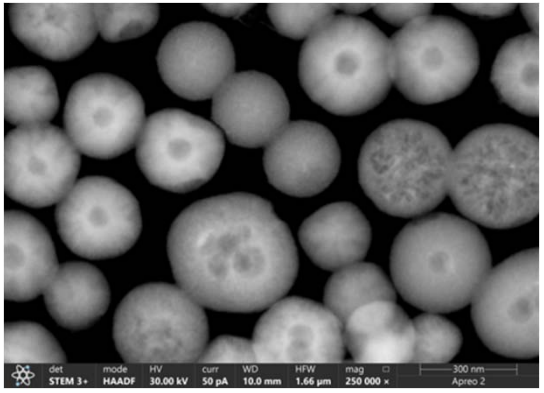
- identyfikacja i degradacja mikrocząstek polimerowych
- sorpcja metali i związków organicznych na mikroplastiku

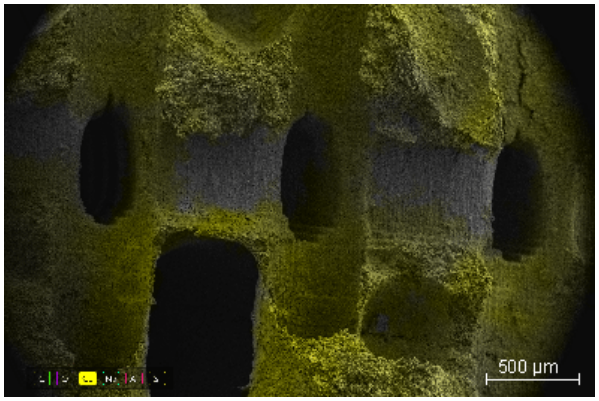
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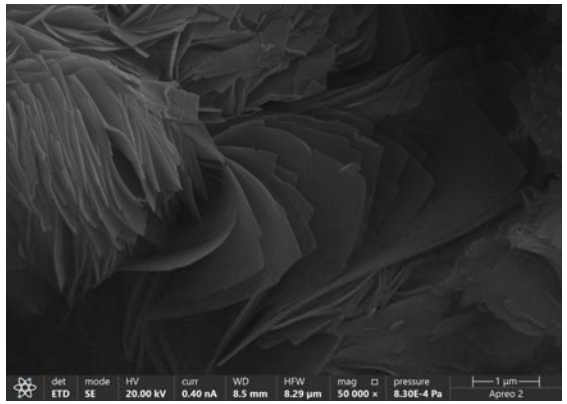
Co zyskujecie?

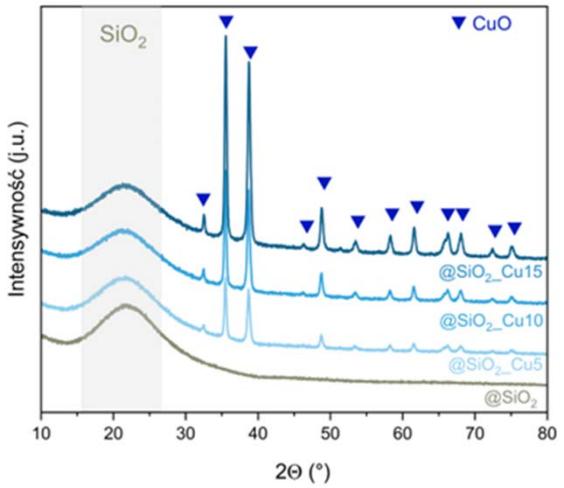
Praktyczne opanowanie szerokiej gamy technik pomiarowych stosowanych w różnie sprofilowanych, nowoczesnych laboratoriach chemicznych

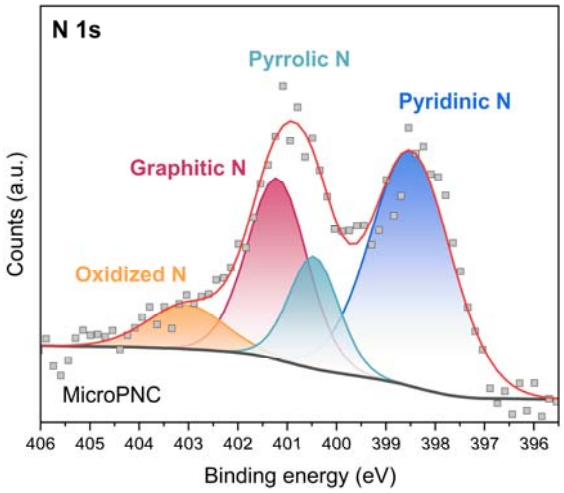
m.in. dyfraktometria proszkowa (XRD), analiza termiczna (TGA), analiza spaleniowa (CHNS-O), fluorescencja rentgenowska (XRF), spektrometria emisyjna ze wzbudzeniem w plazmie indukcyjnie sprzężonej (ICP-OES), spektrometria mas, techniki spektroskopowe (FT-IR, UV-Vis-DR), techniki chromatograficzne (GC, HPLC), techniki temperaturowo-programowane (H_2-TPR, NH_3-TPD)

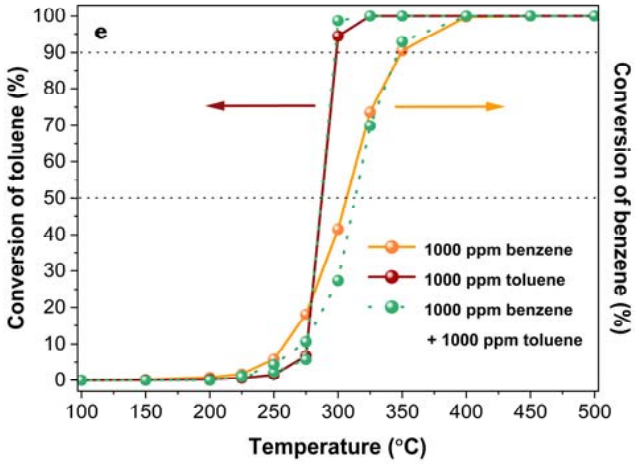












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Co zyskujecie?

Doświadczenie w prowadzeniu syntez materiałów nieorganicznych i organicznych, w tym materiałów polimerowych, jak również umiejętności planowania i realizacji badań aplikacyjnych

- ✓ **praktyczne poznanie strategii projektowania materiałów dedykowanych do konkretnych zastosowań katalitycznych, adsorpcyjnych, elektrochemicznych**
- ✓ **zrozumienie relacji pomiędzy cechami materiałów a ich właściwościami aplikacyjnymi**
- ✓ **umiejętność planowania działań badawczych skoncentrowanych na osiągnięcie zamierzonego celu aplikacyjnego**
- ✓ **zwiększenie kompetencji w zakresie inżynierii chemicznej i środowiskowej**

Selvita

barwa COSMETICS

teva

INGLOT

Grupa Azoty

synthos

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Co zyskujecie?

Otwarcie możliwości współpracy z różnymi ośrodkami naukowymi i przemysłowymi w kraju i zagranicą z opcją wyjazdu na krótko- lub długoterminowe staże badawcze w ramach programów wymiany studenckiej, programów stażowych bądź realizacji agendy projektów badawczych

- ✓ **nawiązywanie relacji z ekspertami z różnych instytucji i krajów**
- ✓ **zdobycie doświadczenia w międzynarodowych zespołach badawczych**
- ✓ **wymiana doświadczeń kulturowych**
- ✓ **podnoszenie kompetencji językowych**

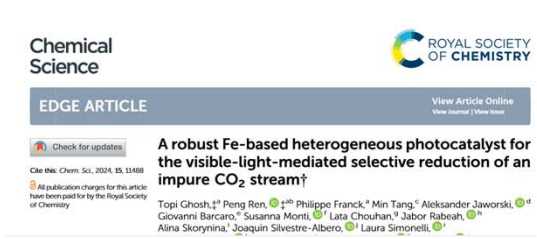


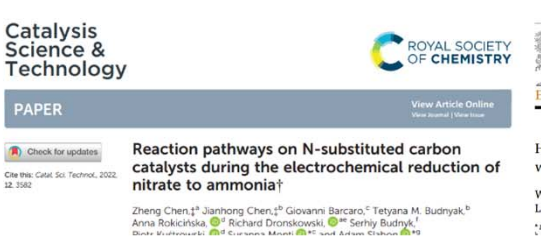
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Co zyskujecie?

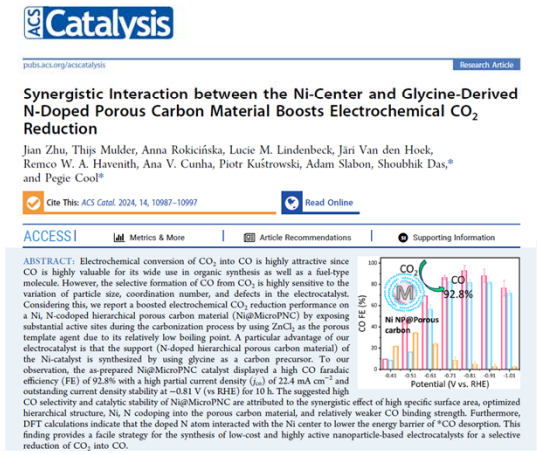
Udział w projektach, publikacjach i patentach

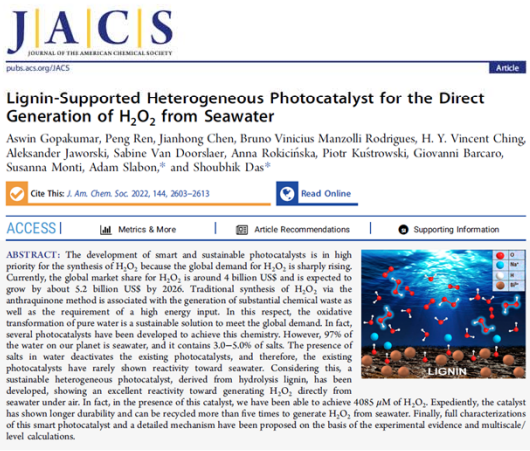

Chemical Science
ROYAL SOCIETY OF CHEMISTRY
EDGE ARTICLE
View Article Online
Check for updates
A robust Fe-based heterogeneous photocatalyst for the visible-light-mediated selective reduction of an impure CO_2 stream†
Topi Ghosh,‡[a] Peng Ren,‡[ab] Philippe Franck,[a] Min Tang,[c] Aleksander Jaworski,[d] Giovanni Barcaro,[e] Susanna Monti,[f] Lata Chouhan,[g] Jabor Rabeah,[h] Alina Skorynina,[i] Joaquin Silvestre-Albero,[j] Laura Simonelli,[i]

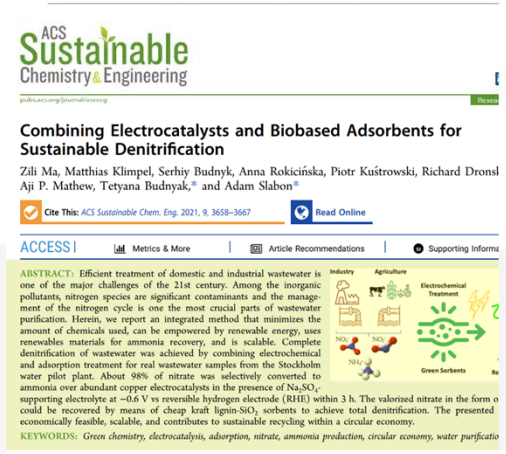

Catalysis Science & Technology
ROYAL SOCIETY OF CHEMISTRY
PAPER
View Article Online
Check for updates
Reaction pathways on N-substituted carbon catalysts during the electrochemical reduction of nitrate to ammonia†
Zheng Chen,‡[a] Jianhong Chen,‡[b] Giovanni Barcaro,[c] Tetyana M. Budnyak,[b] Anna Rokicińska,[d] Richard Dronskowski,[e] Serhiy Budnyk,[f]

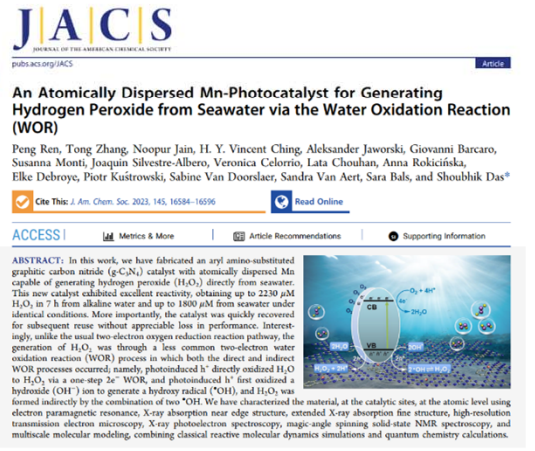

Applied Materials Today 41 (2024) 102473
Contents lists available at ScienceDirect
Applied Materials Today
journal homepage: www.elsevier.com/locate/apmt
House-of-cards composites of MWW monolayers and TiO_2 nanoparticles with (photo)catalytic activity
Wiktoria Dubiel[a,b], Marcin Kobielusz[a], Krystian Mróz[a,b], Michał Mazur[c], Li Ang[c], Lucjan Chmielarz[a], Wojciech Macyk[a], Wiesław J. Roth[a], Jiří Čejka[c], Barbara Gil[a,*]


Chemical Engineering Journal 400 (2024) 140173
Contents lists available at ScienceDirect
Chemical Engineering Journal
journal homepage: www.elsevier.com/locate/cej
Polymer template assisted construction of spherical Co_3O_4@*meso*-SiO_2 yolk-shell nanoreactors for catalytic combustion of volatile organic compounds
Anna Rokicińska[a,*], Piotr Łątka[a], Bazyli Olszański[a], Magdalena Żurowska[a,b], Marek Dębosz[a], Marek Michalik[c], Piotr Kuśtrowski[a,*]


ACS Catalysis
pubs.acs.org/acscatalysis
Research Article
Synergistic Interaction between the Ni-Center and Glycine-Derived N-Doped Porous Carbon Material Boosts Electrochemical CO_2 Reduction
Jian Zhu, Thijs Mulder, Anna Rokicińska, Lucie M. Lindenbeck, Jari Van den Hoek, Remco W. A. Havenith, Ana V. Cunha, Piotr Kuśtrowski, Adam Slabon, Shoubhik Das,* and Pegie Cool*
Cite This: ACS Catal. 2024, 14, 10987−10997
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ABSTRACT: Electrochemical conversion of CO_2 into CO is highly attractive since CO is highly valuable for its wide use in organic synthesis as well as a fuel-type molecule. However, the selective formation of CO from CO_2 is highly sensitive to the variation of particle size, coordination number, and defects in the electrocatalyst. Considering this, we report a boosted electrochemical CO_2 reduction performance on a Ni, N-codoped hierarchical porous carbon material (Ni@MicroPNC) by exposing substantial active sites during the carbonization process by using $ZnCl_2$ as the porous template agent due to its relatively low boiling point. A particular advantage of our electrocatalyst is that the support (N-doped hierarchical porous carbon material) of the Ni-catalyst is synthesized by using glycine as a carbon precursor. To our observation, the as-prepared Ni@MicroPNC catalyst displayed a high CO faradaic efficiency (FE) of 92.8% with a high partial current density (j_{co}) of 22.4 mA cm^{-2} and outstanding current density stability at −0.81 V (vs RHE) for 10 h. The suggested high CO selectivity and catalytic stability of Ni@MicroPNC are attributed to the synergistic effect of high specific surface area, optimized hierarchical structure, Ni, N codoping into the porous carbon material, and relatively weaker CO binding strength. Furthermore, DFT calculations indicate that the doped N atom interacted with the Ni center to lower the energy barrier of *CO desorption. This finding provides a facile strategy for the synthesis of low-cost and highly active nanoparticle-based electrocatalysts for a selective reduction of CO_2 into CO.


J A C S
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
pubs.acs.org/JACS
Article
Lignin-Supported Heterogeneous Photocatalyst for the Direct Generation of H_2O_2 from Seawater
Aswin Gopakumar, Peng Ren, Jianhong Chen, Bruno Vinicius Manzolli Rodrigues, H. Y. Vincent Ching, Aleksander Jaworski, Sabine Van Doorslaer, Anna Rokicińska, Piotr Kuśtrowski, Giovanni Barcaro, Susanna Monti, Adam Slabon,* and Shoubhik Das*
Cite This: J. Am. Chem. Soc. 2022, 144, 2603−2613
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ABSTRACT: The development of smart and sustainable photocatalysts is in high priority for the synthesis of H_2O_2 because the global demand for H_2O_2 is sharply rising. Currently, the global market share for H_2O_2 is around 4 billion US$ and is expected to grow by about 5.2 billion US$ by 2026. Traditional synthesis of H_2O_2 via the anthraquinone method is associated with the generation of substantial chemical waste as well as the requirement of a high energy input. In this respect, the oxidative transformation of pure water is a sustainable solution to meet the global demand. In fact, several photocatalysts have been developed to achieve this chemistry. However, 97% of the water on our planet is seawater, and it contains 3.0−5.0% of salts. The presence of salts in water deactivates the existing photocatalysts, and therefore, the existing photocatalysts have rarely shown reactivity toward seawater. Considering this, a sustainable heterogeneous photocatalyst, derived from hydrolysis lignin, has been developed, showing an excellent reactivity toward generating H_2O_2 directly from seawater under air. In fact, in the presence of this catalyst, we have been able to achieve 4085 μM of H_2O_2. Expediently, the catalyst has shown longer durability and can be recycled more than five times to generate H_2O_2 from seawater. Finally, full characterizations of this smart photocatalyst and a detailed mechanism have been proposed on the basis of the experimental evidence and multiscale/level calculations.


ACS Sustainable Chemistry & Engineering
pubs.acs.org/journal/ascecg
Combining Electrocatalysts and Biobased Adsorbents for Sustainable Denitrification
Zili Ma, Matthias Klimpel, Serhiy Budnyk, Anna Rokicińska, Piotr Kuśtrowski, Richard Dronsk, Aji P. Mathew, Tetyana Budnyak,* and Adam Slabon*
Cite This: ACS Sustainable Chem. Eng. 2021, 9, 3658−3667
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ABSTRACT: Efficient treatment of domestic and industrial wastewater is one of the major challenges of the 21st century. Among the inorganic pollutants, nitrogen species are significant contaminants and the management of the nitrogen cycle is one the most crucial parts of wastewater purification. Herein, we report an integrated method that minimizes the amount of chemicals used, can be empowered by renewable energy, uses renewables materials for ammonia recovery, and is scalable. Complete denitrification of wastewater was achieved by combining electrochemical and adsorption treatment for real wastewater samples from the Stockholm water pilot plant. About 98% of nitrate was selectively converted to ammonia over abundant copper electrocatalysts in the presence of Na_2SO_4-supporting electrolyte at −0.6 V vs reversible hydrogen electrode (RHE) within 3 h. The valorined nitrate in the form o could be recovered by means of cheap kraft lignin-SiO_2 sorbents to achieve total denitrification. The presented economically feasible, scalable, and contributes to sustainable recycling within a circular economy.
KEYWORDS: Green chemistry, electrocatalysis, adsorption, nitrate, ammonia production, circular economy, water purificatio


J A C S
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
pubs.acs.org/JACS
Article
An Atomically Dispersed Mn-Photocatalyst for Generating Hydrogen Peroxide from Seawater via the Water Oxidation Reaction (WOR)
Peng Ren, Tong Zhang, Noopur Jain, H. Y. Vincent Ching, Aleksander Jaworski, Giovanni Barcaro, Susanna Monti, Joaquin Silvestre-Albero, Veronica Celorrio, Lata Chouhan, Anna Rokicińska, Elke Debroye, Piotr Kuśtrowski, Sabine Van Doorslaer, Sandra Van Aert, Sara Bals, and Shoubhik Das*
Cite This: J. Am. Chem. Soc. 2023, 145, 16584−16596
Read Online
ACCESS | Metrics & More | Article Recommendations | Supporting Information
ABSTRACT: In this work, we have fabricated an aryl amino-substituted graphitic carbon nitride (g-C_3N_4) catalyst with atomically dispersed Mn capable of generating hydrogen peroxide (H_2O_2) directly from seawater. This new catalyst exhibited excellent reactivity, obtaining up to 2230 μM H_2O_2 in 7 h from alkaline water and up to 1800 μM from seawater under identical conditions. More importantly, the catalyst was quickly recovered for subsequent reuse without appreciable loss in performance. Interestingly, unlike the usual two-electron oxygen reduction reaction pathway, the generation of H_2O_2 was through a less common two-electron water oxidation reaction (WOR) process in which both the direct and indirect WOR processes occurred; namely, photoinduced h^+ directly oxidized H_2O to H_2O_2 via a one-step $2e^-$ WOR, and photoinduced h^+ first oxidized a hydroxide (OH^-) ion to generate a hydroxy radical (•OH), and H_2O_2 was formed indirectly by the combination of two •OH. We have characterized the material, at the catalytic sites, at the atomic level using electron paramagnetic resonance, X-ray absorption near edge structure, extended X-ray absorption fine structure, high-resolution transmission electron microscopy, X-ray photoelectron spectroscopy, magic-angle spinning solid-state NMR spectroscopy, and multiscale molecular modeling, combining classical reactive molecular dynamics simulations and quantum chemistry calculations.

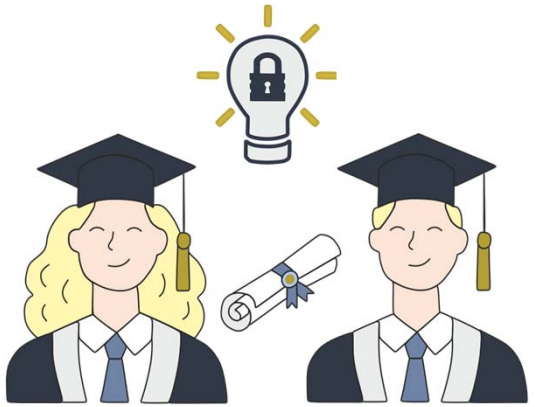
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PRIORITY RESEARCH AREA Anthropocene

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Narodowe Centrum Badań i Rozwoju

FNP Foundation for Polish Science



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Zakład Technologii Chemicznej

Zespół Technologii Organicznej



piotr.kustrowski@uj.edu.pl



Zespół Chemicznych Technologii Środowiskowych



lucjan.chmielarz@uj.edu.pl