XXXIV Konferencja
17-20.10.2021 Zakopane
z cyklu: Zagadnienia surowców energetycznych i energii w gospodarce krajowej
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POLITECHNIKA LUBELSKA
LUBLIN UNIVERSITY OF TECHNOLOGY

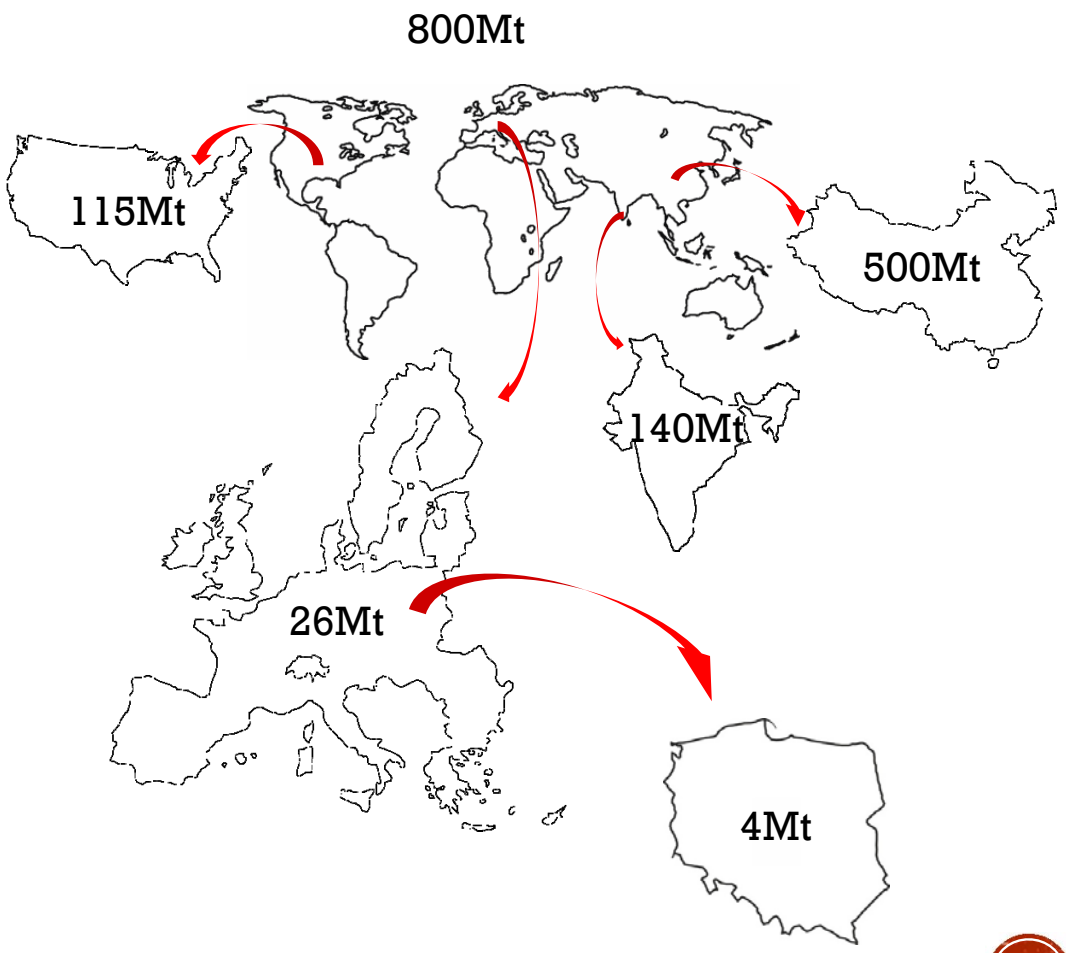
MATERIAŁY POROWATE OTRZYMYWANE Z POPIOŁÓW LOTNYCH - SYNTEZA I ZASTOSOWANIE

1

Wojciech Franus, Jarosław Madej, Rafał Panek

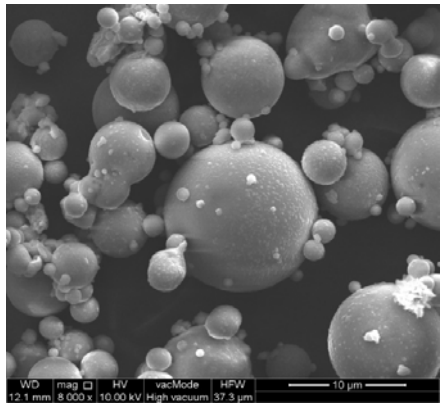
POPIOŁY LOTNE

- Popiół lotny (PL) to najdrobniejsza frakcja odpadów stałych powstających podczas energetycznego spalania węgla w elektrowniach i elektrociepłowniach. Popioły są wyprowadzane strumieniem gazów spalinowych z komory paleniskowej i wychwytywane na filtrach.



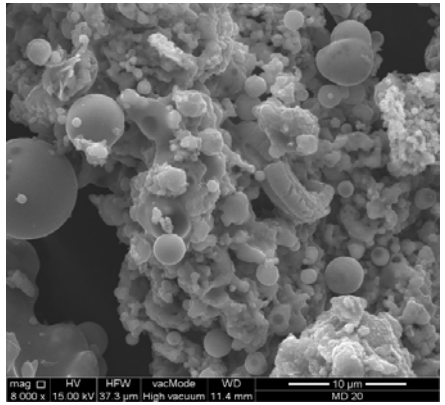
POPIOŁY LOTNE - RODZAJE

Parametr	Klasa F	Klasa C
Typ węgla	kamienny	brunatny
$SiO_2+Al_2O_3+Fe_2O_3$ min. [%]	70	50
CaO min. [%]	-	10
SO_3 min. [%]	5	5



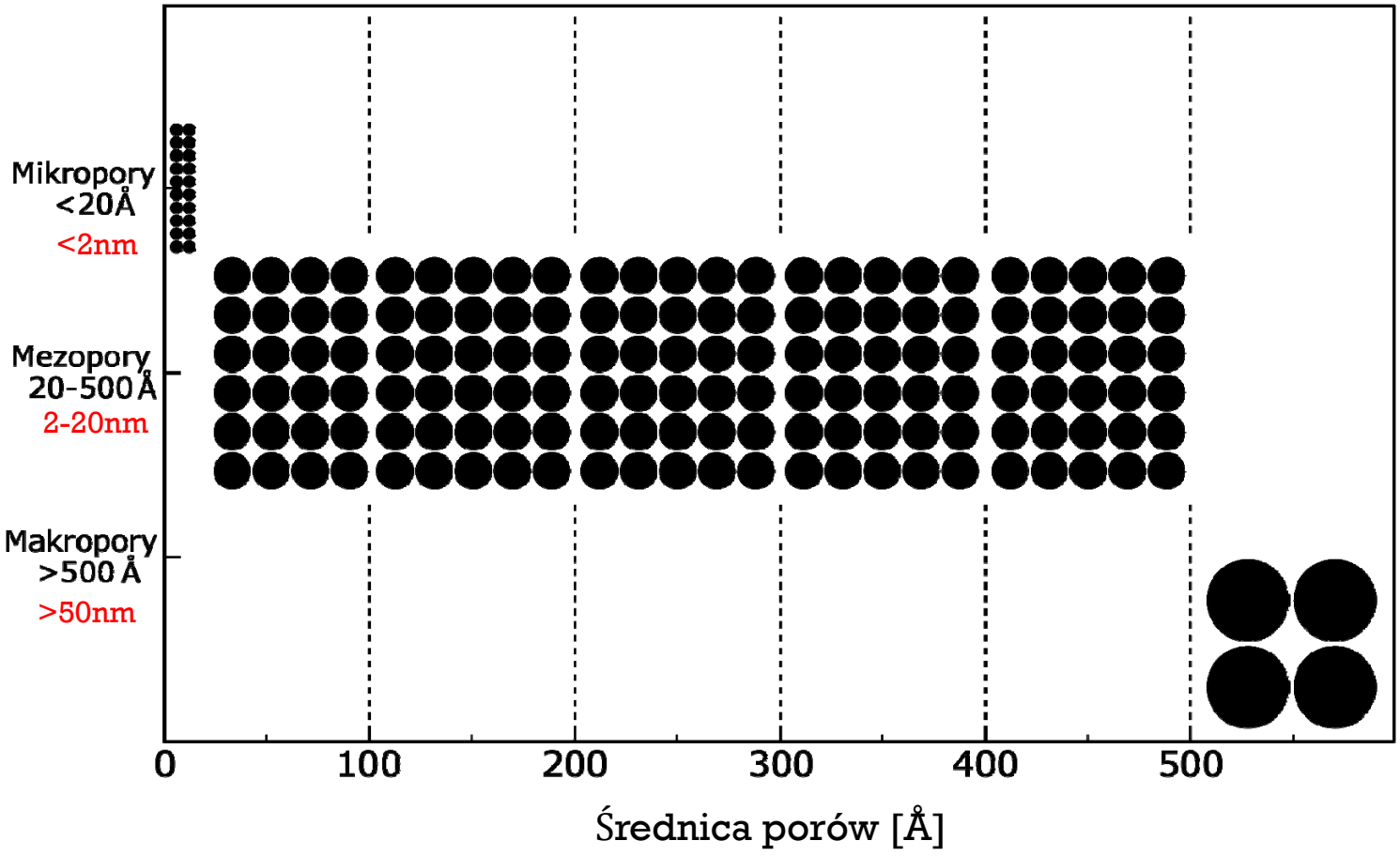
POPIÓŁ LOTNY KLASY F

POPIÓŁ LOTNY KLASY C

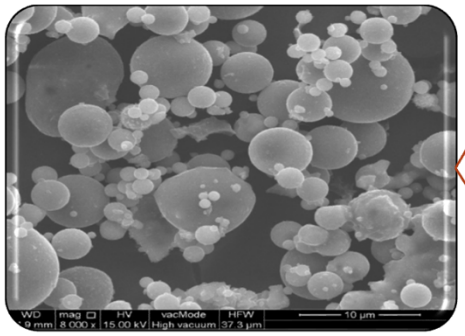


POPIOŁY LOTNE – APLIKACJE I PROBLEMY

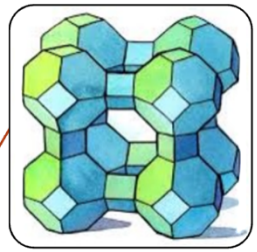
TYPY MATERIAŁÓW



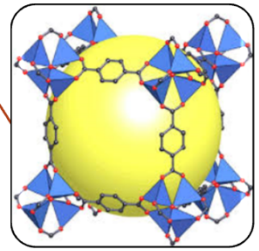
TYPY MATERIAŁÓW



POPIÓŁ LOTNY

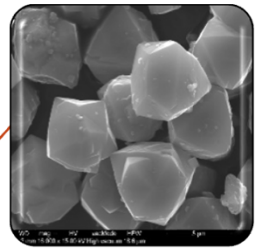


MATERIAŁ ZEOLITOWY

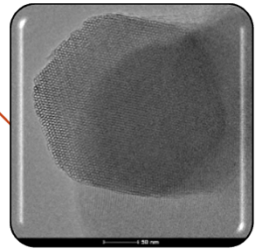


MOF

ROZTWÓR POREAKCYJNY

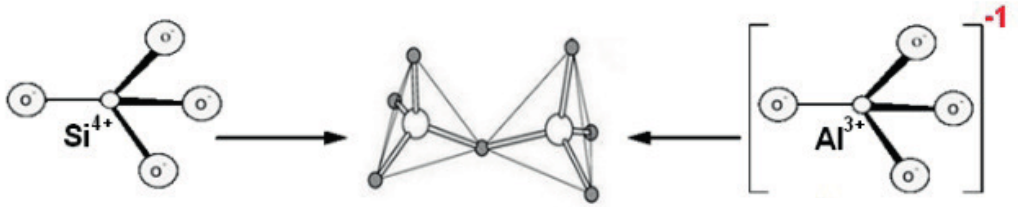


ZEOLIT ULTRACZYSTY

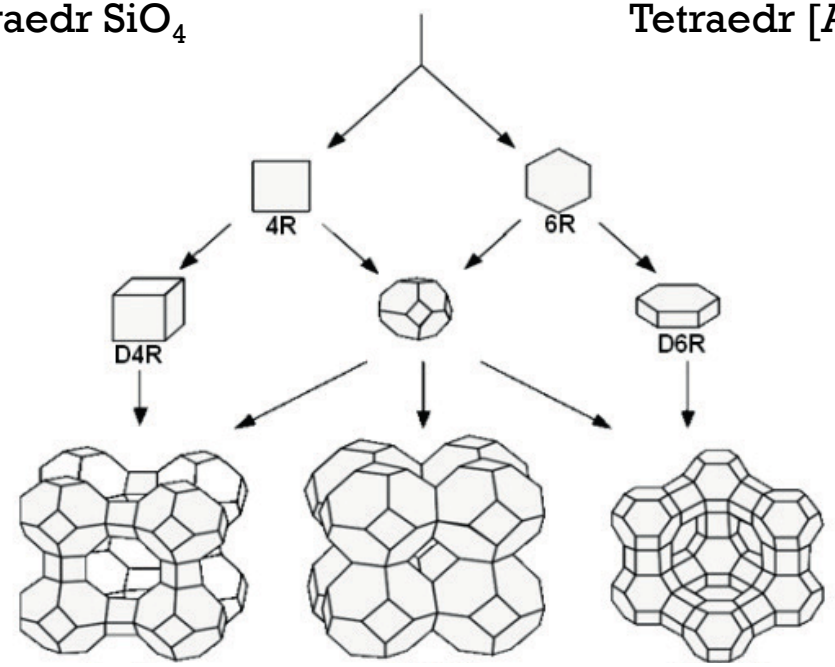


MEZOPOROWATY MATERIAŁ KRZEMIONKOWY

ZEOLITY



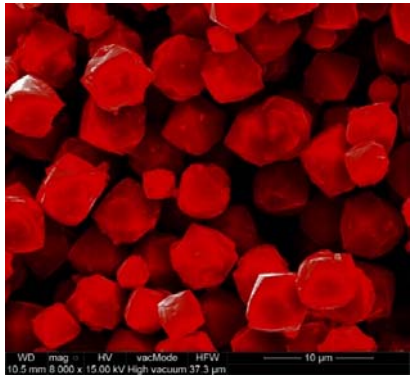
Tetraedr SiO_4 Tetraedr $[AlO_4]^{-1}$



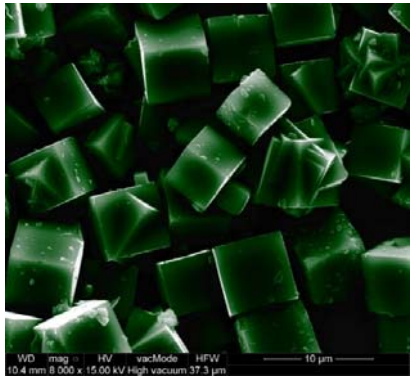
Zeolit A Sodalit Faujazyt

ZEOLITY

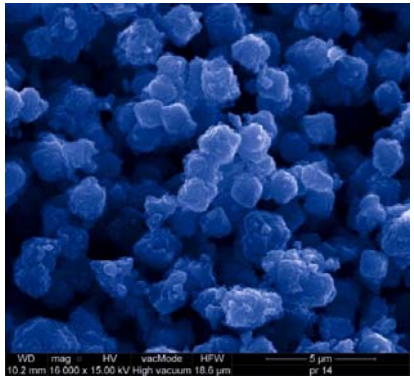
$$\text{PL} + \text{NaOH}_{aq} \xrightarrow[\text{temperatura}]{\text{czas}} \text{zeolit} + \text{residuum}$$



Na-X
7,4 x 7,4 Å

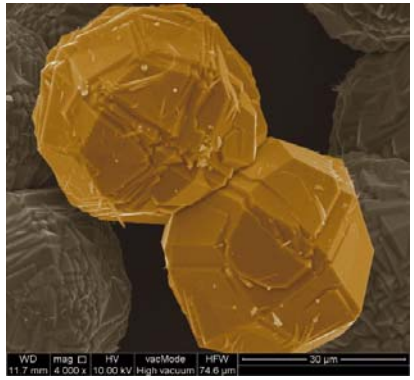


Linde A
4,1 x 4,1 Å



Na-P1
4,5 x 3,1 Å
4,8 x 2,8 Å

Sodalit
2,2 x 2,2 Å



Analcym
1,6 x 4,2 Å

INSTALACJA DO SYNTEZ ZEOLITÓW POPIOŁOWYCH

XXXIV Konferencja 17-20.10.2021 Zakopane
z cyklu: Zagadnienia surowców energetycznych i energii w gospodarce krajowej
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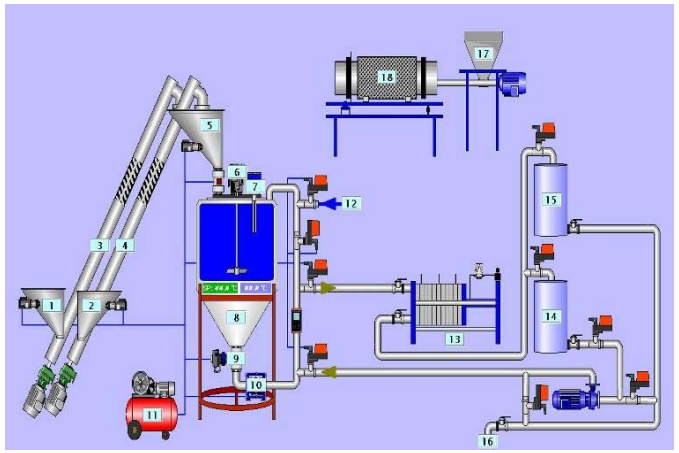


Synthesis and characterization of zeolites prepared from industrial fly ash

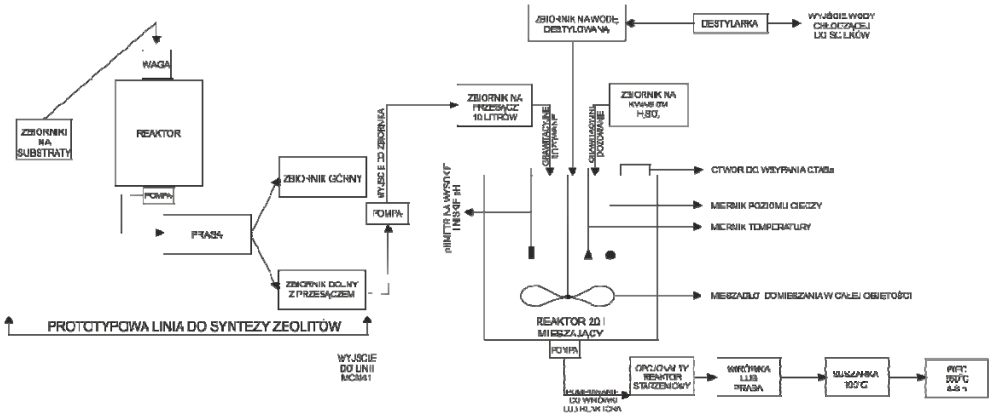
Wojciech Franus · Magdalena Wdowin · Małgorzata Franus

Franus W., Wdowin M., Franus M., Synthesis and characterization of zeolites prepared from industrial fly ash,Environ. Monit. Assess., 186 (2014) 5721-5729.

Pat.224734

INSTALACJA DO SYNTEZ ZEOLITÓW ULTRACZYSTYCH

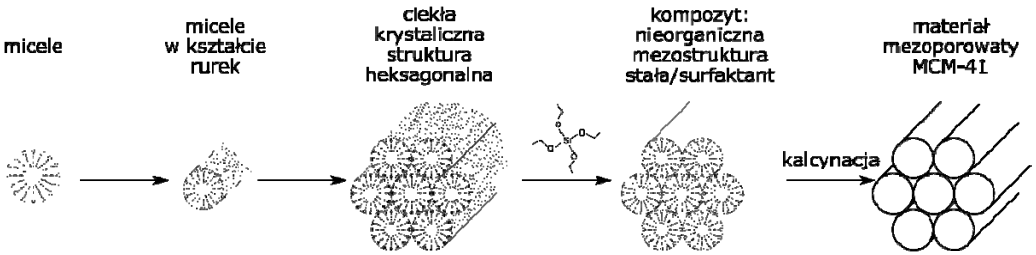
XXXIV Konferencja
17-20.10.2021 Zakopane
www.min-pan.krakow.pl/se
z cyklu: Zagadnienia surowców energetycznych i energii w gospodarce krajowej



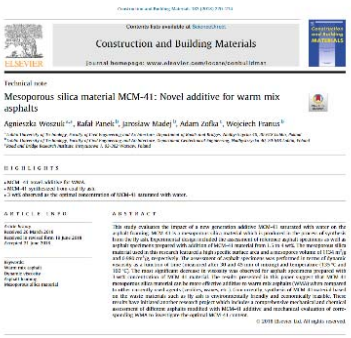

materials
MDPI
Article
Recycling of Waste Solution after Hydrothermal Conversion of Fly Ash on a Semi-Technical Scale for Zeolite Synthesis
Rafał Panek, Jarosław Madej, Lidia Bandura and Grzegorz Słowik

Panek R., Madej J., Bandura L., Słowik G., Recycling of Waste Solution after Hydrothermal Conversion of Fly Ash on a Semi-Technical Scale for Zeolite Synthesis, Materials, 14(6) (2021) 1413

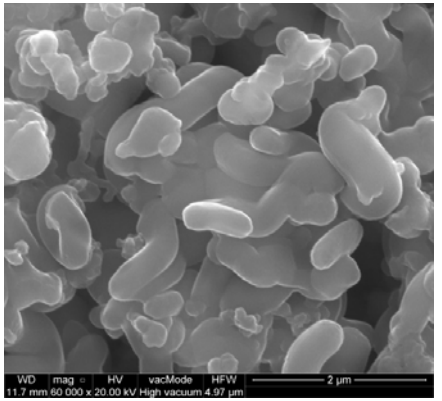
MEZOPOROWATE MATERIAŁY KRZEMIONKOWE

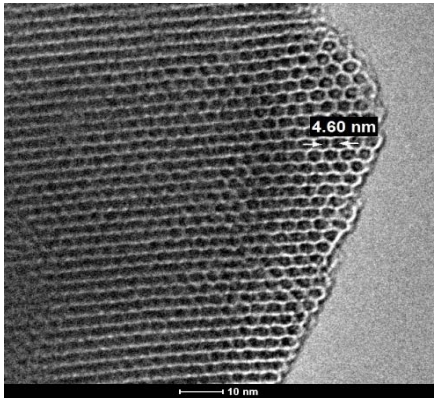


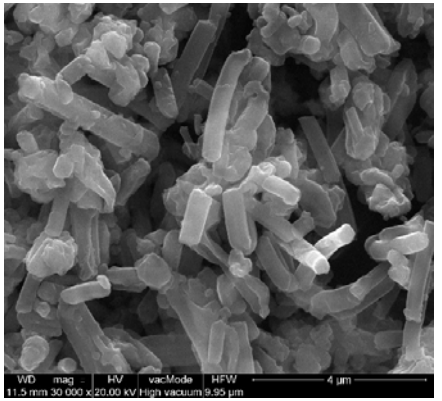
- rozwinięta powierzchnia właściwa (>700 m^2/g)
- obecność uporządkowanych mezoporów (<30nm)
- duża stabilność hydrotermalna
- łatwa funkcjonalizacja powierzchni wieloma grupami funkcyjnymi
- możliwość wprowadzania nanocząstek

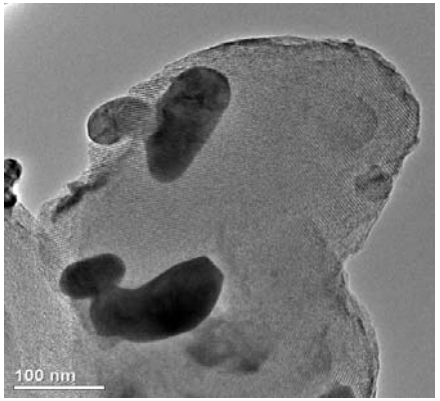

Construction and Building Materials
Mesoporous silica material MCM-41: Novel additive for warm mix asphalts

Woszuk A., Panek R., Madej J., Zofka A., Franus W., Mesoporous silica material MCM-41: Novel additive for warm mix asphalts, Constr. Build. Mater., 183 (2018) 270-274



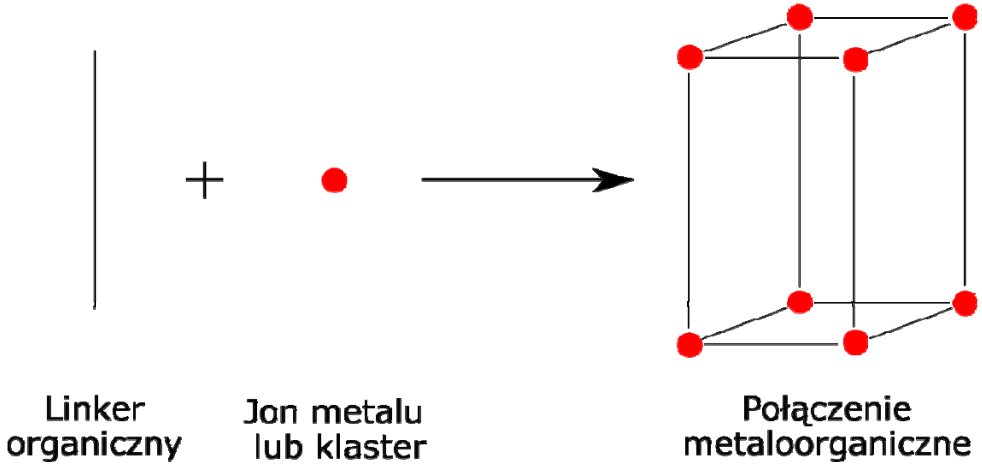


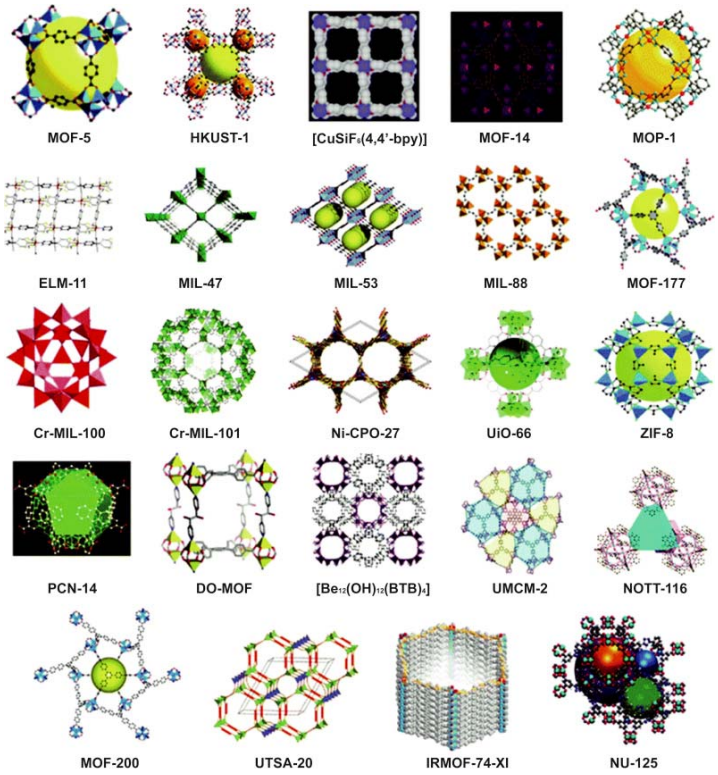




METAL ORGANIC FRAMEWORKS

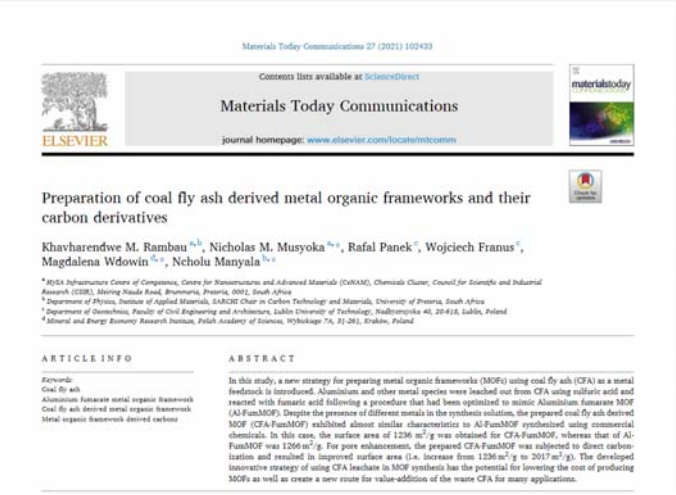
- To klasa związków składających się z jonów metali lub klastrów skoordynowanych z ligandami organicznymi tworząc jedno-, dwu- lub trójwymiarowe struktury. Są podklasą polimerów skoordynowanych bardzo często porowatych.





Linkery: Kwas fumarowy, kwas tereftalowy, Bipirydyna

METAL ORGANIC FRAMEWORKS



Materials Today Communications 27 (2021) 102433

Contents lists available at ScienceDirect

Materials Today Communications

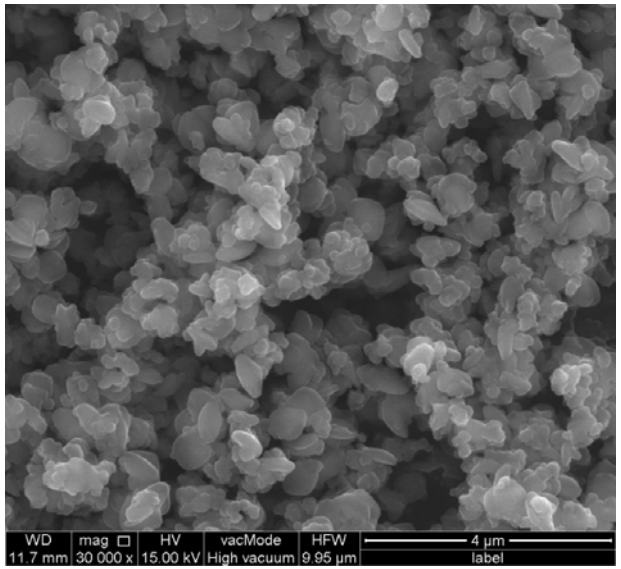
journal homepage: www.elsevier.com/locate/mtcomm

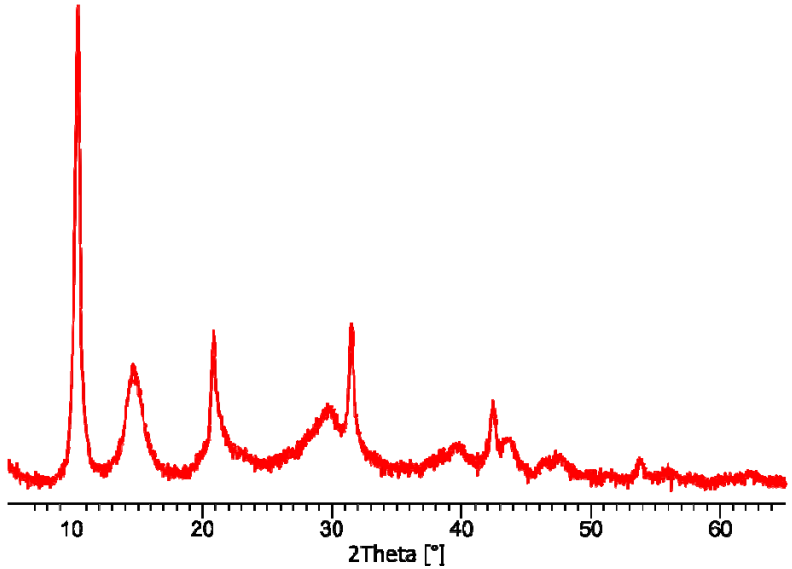
Preparation of coal fly ash derived metal organic frameworks and their carbon derivatives

Khavharendwe M. Rambau [a,b], Nicholas M. Musyoka [a,*], Rafal Panek [c], Wojciech Franus [c], Magdalena Wdowin [d,e], Ncholu Manyala [b,*]

ARTICLE INFO

ABSTRACT





Rambau K.M., Musyoka N.M., Panek R., Franus W., Wdowin M., Manyala N., Preparation of coal fly ash derived metal organic frameworks and their carbon derivatives, Mater. Today Commun., 27 (2021) 102433.

APLIKACJE

XXXIV Konferencja
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Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Effect of zeolite properties on asphalt foaming

Agnieszka Woszuk [a,*], Adam Zofka [b], Lidia Bandura [c], Wojciech Franus [c]

HIGHLIGHTS

- Synthetic zeolites from fly ashes can be used in asphalt foaming technology.
- The efficiency of asphalt foaming depends on the type of zeolite structure/property.
- DTA/TG assesses amount and timing of water release from zeolite during foaming process.

ARTICLE INFO

Article history:
Received: 3 January 2017
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Keywords:
Warm Mix Asphalt
Natural zeolite
Synthetic zeolite
Dynamic viscosity
Foam asphalt

ABSTRACT

This study includes investigation of two zeolite additives to non-modified asphalt binder and associated foaming phenomena. Two zeolites differ in their crystalline structures, i.e. one was Na-P1 synthetic zeolite and second was clinoptilolite natural zeolite. Prior to asphalt foaming these materials were additionally soaked with water which resulted in total of four base materials for laboratory investigation. The amount of zeolite dosed to the asphalt binder was 5% with respect to asphalt mass. The foaming effect was examined in terms of dynamic viscosity and further analyzed as a function of physical and chemical properties of both zeolites. In conclusion it was noted that the foaming effect strongly depends on the amount of water in zeolite structure, mode of its release with time, type of exchangeable cations as well as silicone to aluminum ratio in zeolites and finally their texture properties.

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minerals

MDPI

Article

Use of Spent Zeolite Sorbents for the Preparation of Lightweight Aggregates Differing in Microstructure

Wojciech Franus [1,*], Grzegorz Jozefaciuk [2], Lidia Bandura [1] and Malgorzata Franus [1]

[1] Department of Geotechnical Science, Faculty of Civil Engineering and Architecture, Lublin University of Technology, Nadbystrzycka 40, 20-618 Lublin, Poland; l.bandura@pollub.pl (L.B.); m.franus@pollub.pl (M.F.)

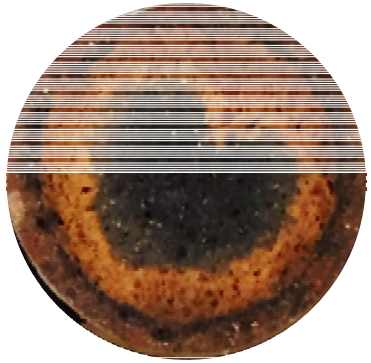
[2] Department of Physical Chemistry of Porous Materials, Institute of Agrophysics, Polish Academy of Sciences, Doświadczalna 4, 20-290 Lublin, Poland; g.jozefaciuk@ipan.lublin.pl

* Correspondence: w.franus@pollub.pl; Tel.: +48-81-538-4416

Academic Editor: Peng Yuan
Received: 9 January 2017; Accepted: 12 February 2017; Published: 17 February 2017

Abstract: Lightweight aggregates (LWAs) made by sintering beidellitic clay deposits at high temperatures, with and without the addition of spent zeolitic sorbents (clinoptilolitic tuff and Na-P1 made from fly ash) containing diesel oil, were investigated. Mineral composition of the aggregates determined by X-ray diffraction was highly uniformized in respect of the initial composition of the substrates. The microstructure of the LWAs, which were studied with a combination of mercury porosimetry, microtomography, nitrogen adsorption/desorption isotherms and scanning electron microscopy, was markedly modified by the spent zeolites, which diminished bulk densities, increased porosities and pore radii. The addition of zeolites decreased water absorption and the compressive strength of the LWAs. The spent Na-P1 had a greater effect on the LWAs' structure than the clinoptilolite.

Keywords: lightweight aggregate; spent sorbents; petroleum; mercury porosimetry; microtomography; porosity



- dodatek przy produkcji kruszyw

- dodatek do zapraw i tynków renowacyjnych

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

The microstructural and physical properties of renovation renders with clinoptilolite, Na-P1 and Na-X zeolites

Joanna Styczeń [a], Danuta Barnat-Hunek [a], Rafał Panek [b], Wojciech Franus [b,*]

HIGHLIGHTS

- New renders for salinated walls have been designed by using synthetic zeolite.
- Synthetic zeolites increased the adhesion to the render surface.
- SPE of renders with zeolites indicates their good hydrophilicity.
- The Na-X zeolite has high resistance to salt crystallization.

ARTICLE INFO

Article history:
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Keywords:
Zeolite
Synthetic zeolites
Render
Frost resistance
Salt crystallization
Microstructure

ABSTRACT

Renovation renders are systems with drying and desalinating functions. The paper was aimed at investigating the influence of adding two different types of synthetic zeolites (Na-X, Na-P1) and natural zeolite (clinoptilolite) on the properties of the base layer of renovation renders. The material was also modified with perlite. The highest compressive strength (4.58 N/mm^2) was achieved by the renders with clinoptilolite. The superior frost resistance was obtained by the renders without perlite addition (0.96% for clinoptilolite, 1.03% for Na-P1 and 1.53% for Na-X). The lowest mass loss after the salt test occurred in the render with Na-X zeolite and reached 4.3%. The renders with natural zeolite were characterized by the mass loss in the range as low as 0.21–0.45%.

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APLIKACJE

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Vol. 47 no. 2 pp. 3–19
PL ISSN 2083-4772
DOI 10.24425/aep.2021.137274

Effective removal of odors from air with polymer nonwoven structures doped by porous materials to use in respiratory protective devices

Agnieszka Brochocka[1], Aleksandra Nowak[1], Rafał Panek[2], Paweł Kozikowski[1], Wojciech Franus[1]*

[1]Central Institute for Labour Protection-National Research Institute, Lodz, Poland
[2]Lublin University of Technology, Lublin, Poland

*Corresponding author's e-mail: wfranus@poczta.pl

Keywords: Activated carbon, zeolites, porous materials, polymer nonwoven structures, mesoporous silica materials, aplication

Abstract: Filtering Respiratory Protective Devices (FRPD) is not typically evaluated for exposure to volatile compounds, even though they significantly affect their protective performance. Such compounds are released into the atmosphere by industrial processes and pose serious health risks in people inhaling them. The adsorbent materials currently used to prevent those risks include activated carbon (AC). Zeolites and mesoporous silica materials (MCM) are very popular among the sorption materials. Due to their physical and chemical properties, they are able to adsorb significant amounts of volatile compounds from air. The melt-blown technology was used to produce filtering nonwovens with modifiers. As a result, polymer nonwoven structures with modifiers in the form of AC, zeolite (NaP1 type), molecular sieves (5M, 5M 4A) and mesoporous silica materials (MCM-41) were produced. The use of ACs (AC from Zgoda and AC, from Piersch) and their mixtures with others modifiers allowed to obtain satisfactory sorption, protective and utility properties. The longest breakthrough time against cyclohexane (approx. 53 min) was afforded by a variant containing AC, against ammonia (approx. 12 min) for the variant with AC, and a mixture of AC, and MCM-41. In the case of acetone vapor satisfactory breakthrough times were found for the variants with AC, and AC, +5M (~20–25 min.). The present work deals with scientific research to improve workers' and society's health and safety by pursuing a better working life, and creating a safe social environment.

- filtry do ochrony górnych dróg oddechowych

- kataliza (synteza H_2)

INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 46 (2021) 10298–10322

Available online at www.sciencedirect.com
ScienceDirect
journal homepage: www.elsevier.com/locate/he

Sustainable nickel catalyst for the conversion of lignocellulosic biomass to H_2-rich gas

Robert Ryczkowski [a], Joanna Gosciańska [b], Rafał Panek [c], Wojciech Franus [c], Kamila Przybysz [d], Jacek Grams [d,]*

[a] Institute of General and Ecological Chemistry, Faculty of Chemistry, Lodz University of Technology, Żeromskiego 116, 90-924, Lodz, Poland
[b] Faculty of Chemistry, Adam Mickiewicz University in Poznan, Umultowska Poznanskiego 8, 61-614, Poznan, Poland
[c] Department of Geotechnical Engineering, Lublin University of Technology, Nadbystrzycka 40, 20-618, Lublin, Poland
[d] Natural Fibers Advanced Technologies, Wolnosci 42A, 95-327, Lodz, Poland

HIGHLIGHTS

- Sustainable catalyst for high temperature conversion of lignocellulosic biomass.
- Fly ash based zeolites used as supports of Ni catalyst for H_2-rich gas production.
- Modification of Ni/fly ash based zeolite leads to increase in hydrogen production.
- Highest activity of Ni/Na-A modified by La.

ARTICLE INFO

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Nickel catalyst
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Biomass conversion
Fly ash based materials
Zeolites
Pyrolysis

ABSTRACT

The objective of this paper was to design sustainable nickel catalysts supported on selected fly ash based zeolites to thermal processing of lignocellulosic feedstock towards hydrogen-rich gas. Moreover, in order to increase its catalytic performance in the studied process the catalyst supported on the most promising fly ash based zeolite was modified by selected rare-earth and transition metals (La, Fe, Ce, Y, Gd, Zr). The performed measurements exhibited that incorporation of nickel into the structure of zeolite A modified by lanthanum resulted in the most effective production of H_2. The characterization of its physicochemical properties (XRD, TPR, SEM-EDS, TPD-NH_3, BET and TGA-DTA) suggested that large pore size, moderate acidity, increased reducibility of an active phase and higher resistance to coke formation are the main factors responsible for increased activity of this catalyst.

Journal of CO_2 Utilization 22 (2017) 81–90

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Fly ash-derived MCM-41 as a low-cost silica support for polyethyleneimine in post-combustion CO_2 capture

R. Panek[a], M. Wdowin[b,*], W. Franus[a], D. Czarna[b], L.A. Stevens[c], H. Deng[c], J. Liu[c], C. Sun[c], H. Liu[c], C.E. Snape[c]

[a] Department of Geotechnics, Civil Engineering and Architecture Faculty, Lublin University of Technology, Nadbystrzycka 40, 20-618 Lublin, Poland
[b] Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Wybickiego 7A, 31-261 Krakow, Poland
[c] University of Nottingham, Faculty of Engineering, Energy Technologies Building, Jubilee Campus, Nottingham NG7 2TU, United Kingdom

ARTICLE INFO

Keywords:
Fly ash
Rice husk ash
Mesoporous materials
CO_2 adsorption

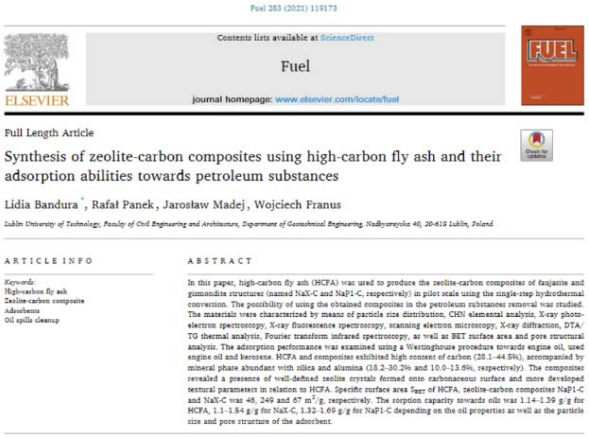
ABSTRACT

The mesoporous silicate molecular sieve, MCM-41, has been synthesized from pulverized coal fly ash (PFA), where the silicate filtrate used is a by product from hydrothermal zeolite production. Rice husk ash was also used for comparison but fusion with sodium hydroxide was used to prepare the silicate filtrate, along similar lines to earlier reports of using PFA as a precursor for MCM-41 synthesis. The MCM-41 samples are chemically and mineralogically similar to a commercially available sample, but with higher pore volumes dominated by mesopores (0.92–1.13 cf. 0.88 $cm^3 g^{-1}$). After polyethyleneimine (PEI) impregnation for CO_2 capture, the ash derived MCM-41 samples displayed higher uptakes than the commercial sample with the maximum achievable PEI loading of 60 Wt.% PEI (dry basis) before particle agglomeration occurs, approximately 13 compared to 11 Wt.%, respectively, the latter being comparable to earlier reports in the literature. The PFA sample that displays the fastest kinetics to achieve 90% of the equilibrium uptake had the largest mesopore volume of 1.13 $cm^3 g^{-1}$. Given the PFA derived MCM-41 uses a waste silicate solution for hydrothermal preparation and no prior preparation is needed, production costs are estimated to be considerable lower where silicate solutions need to be prepared by base treatment, even if ash is used, as for the RHA derived MCM-41 used here.

- usuwanie CO_2

APLIKACJE

- sorbent substancji ropopochodnych


Fuel 283 (2021) 119173

Contents lists available at ScienceDirect

Fuel

journal homepage: www.elsevier.com/locate/fuel

Full Length Article

Synthesis of zeolite-carbon composites using high-carbon fly ash and their adsorption abilities towards petroleum substances

Lidia Bandura*, Rafał Panek, Jarosław Madej, Wojciech Franus

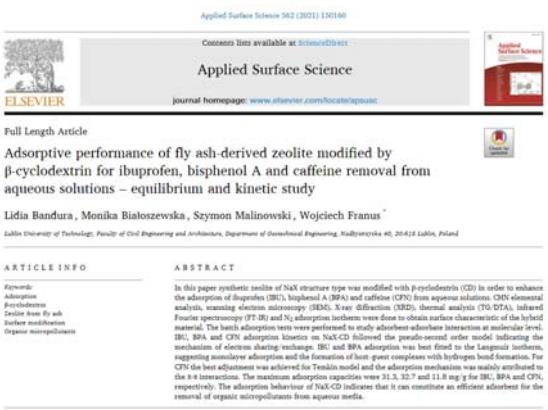
Lublin University of Technology, Faculty of Civil Engineering and Architecture, Department of Geotechnical Engineering, Nadbystrzycka 40, 20-618 Lublin, Poland

ARTICLE INFO

Keywords:
High-carbon fly ash
Zeolite-carbon composite
Adsorbents
Oil spills cleanup

ABSTRACT

In this paper, high-carbon fly ash (HCFA) was used to produce the zeolite-carbon composites of faujasite and gismondite structures (named NaX-C and NaP1-C, respectively) in pilot scale using the single-step hydrothermal conversion. The possibility of using the obtained composites in the petroleum substances removal was studied. The materials were characterized by means of particle size distribution, CHN elemental analysis, X-ray photoelectron spectroscopy, X-ray fluorescence spectroscopy, scanning electron microscopy, X-ray diffraction, DTA/TG thermal analysis, Fourier transform infrared spectroscopy, as well as BET surface area and pore structural analysis. The adsorption performance was examined using a Wettinghouse procedure towards engine oil, used engine oil and kerosene. HCFA and composites exhibited high content of carbon (28.1–44.8%), accompanied by mineral phase abundant with silica and alumina (18.2–30.2% and 10.0–13.6%, respectively). The composites revealed a presence of well-defined zeolite crystals formed onto carbonaceous surface and more developed textural parameters in relation to HCFA. Specific surface area S_{BET} of HCFA, zeolite-carbon composites NaP1-C and NaX-C was 4b, 249 and 67 m^2/g, respectively. The sorption capacity towards oils was 1.14–1.39 g/g for HCFA, 1.1–1.84 g/g for NaX-C, 1.32–1.69 g/g for NaP1-C depending on the oil properties as well as the particle size and pore structure of the adsorbent.


Applied Surface Science 562 (2021) 150160

Contents lists available at ScienceDirect

Applied Surface Science

journal homepage: www.elsevier.com/locate/apsusc

Full Length Article

Adsorptive performance of fly ash-derived zeolite modified by β-cyclodextrin for ibuprofen, bisphenol A and caffeine removal from aqueous solutions – equilibrium and kinetic study

Lidia Bandura, Monika Białoszewska, Szymon Malinowski, Wojciech Franus*

Lublin University of Technology, Faculty of Civil Engineering and Architecture, Department of Geotechnical Engineering, Nadbystrzycka 40, 20-618 Lublin, Poland

ARTICLE INFO

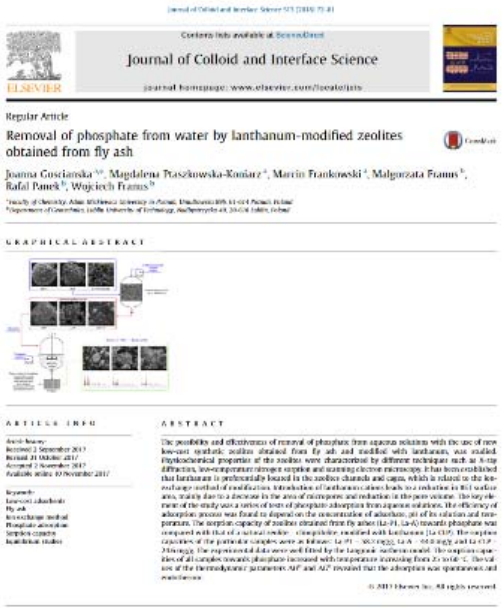
Keywords:
Adsorption
β-cyclodextrin
Zeolite from fly ash
Surface modification
Organic micropollutants

ABSTRACT

In this paper synthetic zeolite of NaX structure type was modified with β-cyclodextrin (CD) in order to enhance the adsorption of ibuprofen (IBU), bisphenol A (BPA) and caffeine (CFN) from aqueous solutions. CHN elemental analysis, scanning electron microscopy (SEM), X-ray diffraction (XRD), thermal analysis (TG/DTA), infrared Fourier spectroscopy (FT-IR) and N_2 adsorption isotherm were done to obtain surface characteristic of the hybrid material. The batch adsorption tests were performed to study adsorbent-adsorbate interaction at molecular level. IBU, BPA and CFN adsorption kinetics on NaX-CD followed the pseudo-second order model indicating the mechanism of electron sharing/exchange. IBU and BPA adsorption was best fitted to the Langmuir isotherm, suggesting monolayer adsorption and the formation of host–guest complexes with hydrogen bond formation. For CFN the best adjustment was achieved for Temkin model and the adsorption mechanism was mainly attributed to the π-π interactions. The maximum adsorption capacities were 31.3, 32.7 and 11.8 mg/g for IBU, BPA and CFN, respectively. The adsorption behaviour of NaX-CD indicates that it can constitute an efficient adsorbent for the removal of organic micropollutants from aqueous media.

- usuwanie farmaceutyków

- usuwanie fosforanów z wód


Journal of Colloid and Interface Science 523 (2018) 73–83

Contents lists available at ScienceDirect

Journal of Colloid and Interface Science

journal homepage: www.elsevier.com/locate/jcis

Regular Article

Removal of phosphate from water by lanthanum-modified zeolites obtained from fly ash

Joanna Goscianska*, Magdalena Ptaszkowska-Koniarz, Martin Frankowski, Małgorzata Franus, Rafał Panek, Wojciech Franus

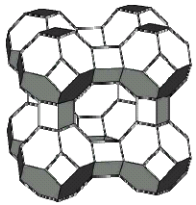
GRAPHICAL ABSTRACT

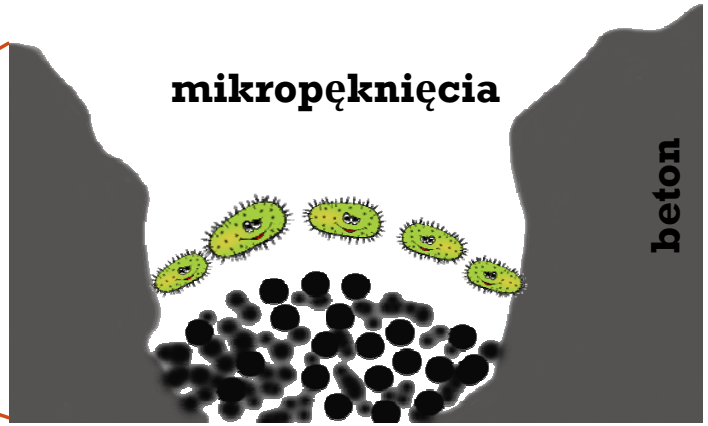
ARTICLE INFO

Keywords:
Lanthanum
Fly ash
Ion exchange method
Phosphate adsorption
Sorption capacity
Isothermal studies

ABSTRACT

INNE APLIKACJE – MATERIAŁY HYBRYDOWE



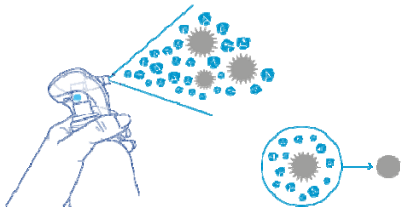


produkty metabolizmu

- **Betony samonaprawiające**
- **Renowacja kamiennych elementów architektonicznych**
- **Stabilizacja geotechniczna gruntów słabonośnych**

proszek

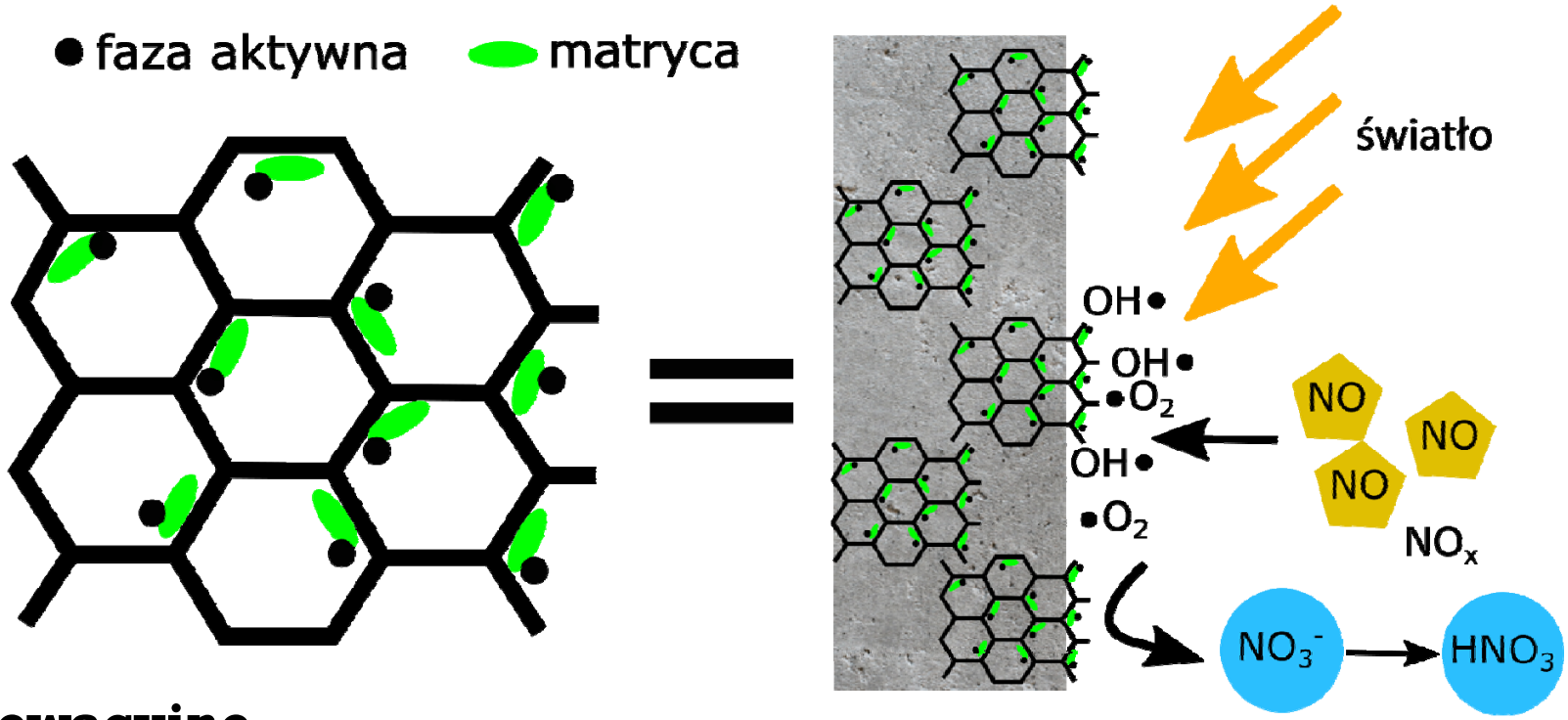
pasta



spray

kapsułki

INNE APLIKACJE – FOTOKATALIZA



- **Farby elewacyjne**
- **Betony architektoniczne**
- **Kostka brukowa**

FNP
Fundacja na rzecz Nauki Polskiej

Popioły lotne jako prekursory materiałów funkcjonalizowanych do zastosowania w inżynierii środowiska, budownictwie i rolnictwie

TEAM-NET

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MATERIALS | SYNTHESIS | APPLICATION

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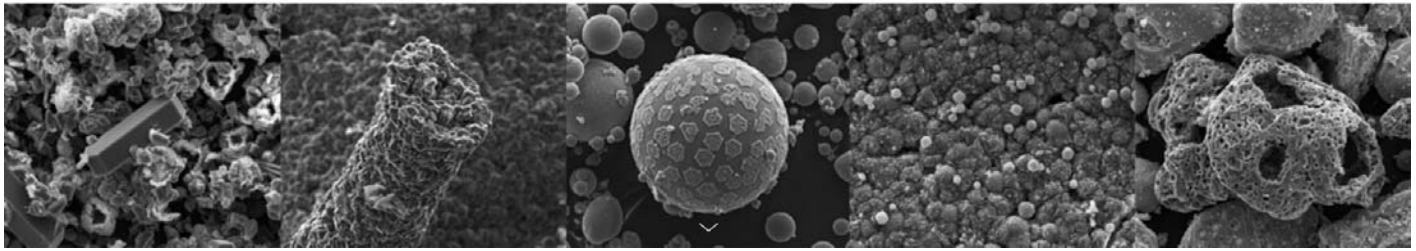

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