BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

New developing green extraction of critical mineral for energy security in Indonesia

Dr. Fathan Bahfie
Research Center of Mineral Technology
Research Group of Mineral Technology on Base and Precious Metal



BRIN
BADAN RISET
DAN INOVASI NASIONAL

RESEARCH CENTER OF MINERAL TECHNOLOGY-BRIN
Research Group for Mineral Technology of Minerals Base and Precious Metals

Dr. Fathan Bahfie, S.T., M.Si.



Scopus
Scopus ID

Citations	Documents	h-index
263	95	9

Google Scholar

Citations	h-index	i10-index
610	13	24

Position: Associate Researcher

Interest Area: Metallurgy extraction, mineral processing, physical metallurgy.

Educational Background:

- Bachelor Degree, Material and Metallurgical Engineering-Institute of Technology Sepuluh Nopember
- Master Degree, Material Science, Universitas Indonesia
- Doctoral Degree, Material Science, Universitas Indonesia

Work Background: Scientist in Indonesian Institute of Science (2014-2021), Lecture as the Practitioner in University of Lampung (2023-now), Supervisor of Optical Characterization Lab (FESEM-EDS) (2021-2025), Fellowship in CSIR-IMMT, India (2023-2024), Visiting Researcher in RMIT-University, Australia (2025), Head of Local Employee Cooperative (2023-now), Research Group for Mineral Technology of Minerals Base and Precious Metals Leader (2025-now).

Working Area: Kawasan Sains Tanjung Bintang, Lampung, Indonesia.

COMMODITIES: Ni, Mn, Co, Ti, Fe, Alloying Material
EXPERTISE: Pyrometallurgy, Hydrometallurgy, Solvent Extraction, Deep Eutectic Solvent, Synthesis, Alloying, Using ICP-OES, FESEM-EDS, XRD, XRF.

Student: Undergraduate student (17), Master (3), Doctor (1)

Teaching: Advance Characterization Material Equipment (XRD and FESEM-EDS)

BRIN
NATIONAL RESEARCH
AND INNOVATION AGENCY

PROFILE OF THE NATIONAL RESEARCH AND INNOVATION AGENCY (BRIN)





8th RD20 2026
South Africa, October 21st, 2026

brin.go.id | @brin_indonesia | @brin.indonesia | @brin.indonesia

HISTORY OF BRIN

BRIN

Based on Presidential Regulation No. 78/2021 concerning BRIN, established on

28 April 2021

The National Research and Innovation Agency (BRIN) is responsible for conducting research, development, assessment, and application, as well as national invention and innovation.

- **LIPI** — Indonesian Institute of Sciences
- **BATAN** — National Nuclear Energy Agency
- **LAPAN** — National Institute of Aeronautics and Space
- **BPPT** — Agency for the Assessment and Application of Technology
- Ministry Research and Development Agencies

BRIN ORGANIZATIONAL STRUCTURE

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

STEERING BOARD
Chair: element of the Steering Board of BPIP
Vice Chair: Minister of Research, Technology, and Higher Education
Members: 6 professional members and/or academics in the field of research

HEAD OF BRIN



Prof. Dr. Arif Satria, S.P., M.Si

DEPUTY HEAD OF BRIN

MAIN INSPECTORATE

- INSPECTORATE I
- INSPECTORATE II
- INSPECTORATE III

MAIN SECRETARIAT

- Bureau of Planning and Finance
- Bureau of Legal Affairs and Cooperation
- Bureau of Organization and Human Resources
- Bureau of Asset Management and Procurement
- Bureau of Public Communication, General Affairs and Secretaiat

DEPUTY FOR HUMAN RESOURCES DEVELOPMENT
- Deputy Secretary
- Directorate of Human Resources Policy, Needs, and Development
- Directorate of Political, Legal, Regulatory Affairs, and Security
- Directorate of Economy, Employment, and Regional Development
- Directorate of Development for Living Environment, Maritime, Natural Resources, and Food Security

DEPUTY FOR RESEARCH POLICY AND INNOVATION
- Deputy Secretary
- Directorate of Formulation of Research, Technology and Innovation Policies
- Directorate of Research and Technology Utilization and Indicators
- Directorate of Research and Innovation Policy Evaluation

DEPUTY FOR RESEARCH INFRASTRUCTURE AND SCIENCE AND TECHNOLOGY FACILITIES
- Deputy Secretary
- Directorate of Competency Development
- Directorate of Functional Position Development and Professional Management
- Directorate of Talent Management

DEPUTY FOR RESEARCH INFRASTRUCTURE AND INNOVATION
- Deputy Secretary
- Directorate of Research Infrastructure Management
- Directorate of Research Fleet Management
- Directorate of Operation and Maintenance of Research Infrastructure and Facilities
- Directorate of Analysis and Testing of Research Facilities and Technology
- Directorate of Efficient Utilization of Research Infrastructure and Facilities

DEPUTY FOR RESEARCH FACILITIES AND INNOVATION
- Deputy Secretary
- Directorate of Research Capability Management
- Directorate of Research Data Management and Information Systems
- Directorate of Scientific Collection Management and Intellectual Property
- Directorate of Multimedia and Publication of Research Results
- Directorate of Research Funding

DEPUTY FOR RESEARCH MANAGEMENT AND INNOVATION
- Deputy Secretary
- Directorate of Research Management Information Systems
- Directorate of Research and Industry Utilization
- Directorate of Research and Community/L Institutional Utilization
- Directorate of Research Partenrships

DEPUTY FOR REGIONAL RESEARCH AND INNOVATION
- Deputy Secretary
- Directorate of Regional Research and Innovation Policy
- Directorate of Regional Research and Innovation Facilities and Infrastructure
- Directorate of Dissemination and Utilization of Regional Research and Innovation

NATIONAL RESEARCH POLYTECHNIC

PUSDATIN

PUSYANTEK

RESEARCH ORGANIZATIONS

- Research Organization for Earth and Maritime
- Research Organization for Life Sciences and Environment
- Research Organization for Agriculture and Food
- Research Organization for Health
- Research Organization for Archaeology, Languages and Literature
- Research Organization for Social Sciences and Humanities
- Research Organization for Nuclear Energy
- Research Organization for Governance, Economy and Society
- Research Organization for Energy and Manufacturing
- Research Organization for Nanotechnology and Materials
- Research Organization for Electronics and Informatics
- Research Organization for Aeronautics and Space

MAIN SECRETARIAT : Administrative and Office Infrastructure Functions
DEPUTIES : Research Infrastructure and Public Services to Produce Outcomes
OR/PR : Research Activities to Produce Outputs

BRIN
RESEARCH ORGANIZATIONS

BerAKHLAK
Competent, Harmonious, Loyal, Adaptive, Collaborative
for a Superior Indonesia

#Serving the Nation with Pride

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

Strengthening and Restructuring Research Functions at BRIN in 2022


Research Organization for Earth and Maritime Sciences


Research Organization for Life Sciences and Environment


Research Organization for Agriculture and Food


Research Organization for Health


Research Organization for Archaeology, Languages and Literature


Research Organization for Social Sciences and Humanities


Research Organization for Nuclear Energy


Research Organization for Governance, Economy and Society


Research Organization for Energy and Manufacturing


Research Organization for Nanotechnology and Materials



Research Organization for Electronics and Informatics


Research Organization for Aeronautics and Space

Source: Presidential Regulation on Research Organizations (2022)

© NATIONAL RESEARCH AND INNOVATION AGENCY (BRIN)

RESEARCH ORGANIZATION FOR NANOTECHNOLOGY AND MATERIALS

Material Innovation • Advanced Technology • Sustainable Future

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

1. Research Center for Mineral Technology
2. Research Center for Metallurgy
3. Research Center for Energy Materials
4. Research Center for Composites and Biomaterials
5. Research Center for Catalysis
6. Research Center for Molecular Chemistry
7. Research Center for Biomass and Bioproducts
8. Research Center for Photonics
9. Research Center for Nanotechnology Systems
10. Research Center for Polymer Technology
11. Research Center for Quantum Physics



Jl. Ir. Sutami Km. 15,
Tanjung Bintang,
South Lampung



BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

RESEARCH COLLABORATION

Synergizing to Build Innovation for a Progressive Indonesia



COLLABORATION PARTNERS

SWINBURNE UNIVERSITY OF TECHNOLOGY
Akita University
九州大学 KYUSHU UNIVERSITY
PennState
UNIVERSITI TEKNOLOGI PETRONAS
ITERA
itk
BukitAsam beyond coal

HUMAN RESOURCES

- Research Internships (MBKM/Undergraduate Thesis/Master's Thesis/Dissertation)
- Research-Based Degree Scholarships
- Postdoctoral & Visiting Researchers

FUNDING

- Innovation Research for a Progressive Indonesia (RIIM Competitive)
- Program House Research / Seed Funding Research
- Research Collaboration Centers
- University Grants

RESEARCH INFRASTRUCTURE

- Open Access Laboratory



Together, Building the Nation | Innovation for Real Solutions | Collaboration for Greater Impact | Towards a Progressive and Sustainable Indonesia

BRIN
BADAN RISET
DAN INOVASI NASIONAL

Pusat Riset Teknologi Mineral
(*Research Center for Mineral Technology*)





HOME BASE:
KST-BJ. Habibie, Puspiptek, Serpong
KST-Iskandar Zulkarnain, Lampung Selatan

PUSAT RISET
TEKNOLOGI MINERAL

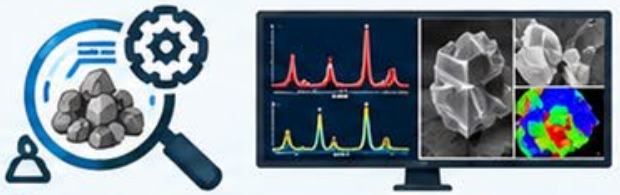
BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

Research Center for Mineral Technology

Minerals and Coal (Primary Resources)



Mineral & Coal Identification (Smart Characterization)



- Mineral identification and characterization
- Advanced analytical techniques (XRD, SEM-EDS, FTIR, Raman, etc.)

Beneficiation Process

(Size reduction, physical, chemical and thermal beneficiation)



Mineral Processing

(Pyro, Hydro, Electro, Bio-metallurgy & Phytomining)



- Extraction and separation of valuable elements
- Pyrometallurgy, hydrometallurgy, electrometallurgy and phytomining

By-products

(Secondary Resources)



Products



High Value Added Products

58 Ce Cerium	66 Dy Dysprosium	68 Er Erbium	63 Eu Europium	64 Gd Gadolinium	67 Ho Holimium
57 La Lanthanum	71 Lu Lutetium	60 Nd Neodymium	59 Pr Praseodymium	61 Pm Promethium	62 Sm Samarium
21 Sc Scandium	65 Tb Terbium	69 Tm Thulium	70 Yb Yttebium	39 Y Yttrium	

Waste Utilization

(Circular Economy)

- Recovery of valuable elements
- Waste valorization
- Environmental sustainability

Urban Mining

(Secondary Resources)



Scope of Research

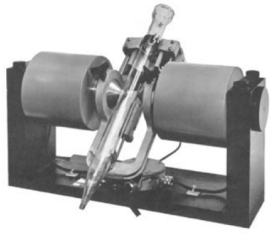
- Mineral identification using smart characteriization methods
- Mineral processing and purification
- Utilization of coal for non-fuel products
- Environmental impacts of mineral processing and urban mining

Researcher Resources

S-1 : 10 researchers (18.9%)
S-2 : 27 researchers (50.9%)
S-3 : 16 researchers (30.2%)

Total Researchers : **53**

(SBSN 2022) Integrated Mineral Processing Laboratory


Davis Tube


Ring Mill


ICP-MS


Jaw Crusher


Mortar Grinder


Planetary Ball Mill

Mineral Characterization Lab.

Hydro-electrometallurgy Lab.

Pyrometallurgy Lab. & Pilot Plant

Bio-metallurgy Lab.

Coal & Non-Metal Processing Lab

Comminution & Beneficiation Lab.

Heat Treatment Lab.


XRD


FE-SEM/EDS


ICP-OES


WD-XRF


FTIR


PSA


LA-LIBS


DSC/TGA

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

PROFILE OF THE RESEARCH CENTER FOR MINERAL TECHNOLOGY



RESEARCH CENTER FOR MINERAL TECHNOLOGY (PRTM)

(Pusat Riset Teknologi Mineral)

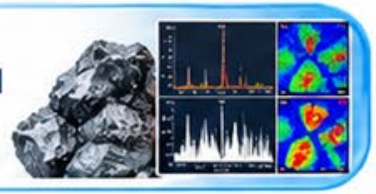
KST Iskandar Zulkarnain, Lampung | KST BJ. Habibie, Serpong

Dr. Fajar Nurjaman
Head of Research Center for Mineral Technology



RESEARCH GROUPS OF PRTM

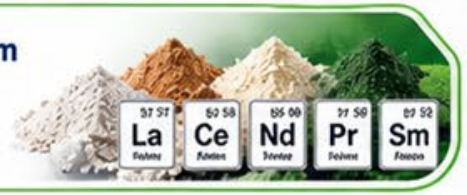
1. **Teknologi Rekayasa dan Identifikasi Cerdas Mineral**
   (Mineral Engineering and Smart Identification of Minerals)



2. **Teknologi Mineral Logam Dasar dan Logam Mulia**
   (Mineral Technology of Base and Precious Metals)



3. **Teknologi Mineral Logam Tanah Jarang**
   (Mineral Technology of Rare Earth Elements)



4. **Teknologi Mineral Non Logam**
   (Non-Metallic Mineral Technology)



5. **Pengelolaan Dampak Pengolahan Mineral**
   (Mineral Processing Impact Management)



6. **Pemanfaatan Batubara non Bahan Bakar**
   (Coal Processing and Utilization)





Advanced Research | Innovative Technology | Sustainable Mining | Strategic Impact

BRIN
for a **Resilient**, Innovative, and Advanced **Indonesia**

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

RESEARCH GROUP OF THE RESEARCH CENTER FOR MINERAL TECHNOLOGY



Mineral Engineering and Smart Identification of Minerals

Mochamad Rifat Noor, S.T., M.Sc.



RESEARCH GROUP MEMBERS

1. Noviarso Wicaksono, S.T.
2. Dr. Fajar Yudi Prabawa, MT
3. Hilmi El Hafidz Fatahillah, S.Si., M.Geo.Sc.
4. Fardy Septiawan, S.Si.
5. Taufiq Widiaputra, S.T.
6. Muhammad Luthfi Aziz, S.T.
7. Mochamad Rifat Noor, S.T., M.Sc.
8. Vany Nursanti, S.T., M.T.
9. Ir. RM. Nendaryono Madiutomo, M.T.
10. Rachmat Ramadhan, M.Si.

DEFINITION:

The Mineral Engineering and Smart Identification of Minerals Research Group conducts research, utilization, and advancement of mineral understanding through the integration of smart identification technologies and mineral engineering principles. The group also focuses on developing automated and intelligent systems for rapid and accurate mineral characterization for innovative applications across the mineral industry.

SCOPE:

1. **Digital engineering and mineral data integration:** developing intelligent methods to accelerate and improve the accuracy of mineral identification.
2. **Intelligent technology-based mineral identification and characterization:** developing deep learning, neural network, and Principal Component Analysis (PCA) algorithms for mineral data analysis.
3. **Automated mineral characterization and modeling:** developing and applying non-destructive technologies for mineral identification and mineral-image modeling based on natural features.
4. **Instrument and sensor development:** developing and utilizing smart sensors for real-time or semi-automated mineral identification.

RESEARCH GROUP FOR MINERAL ENGINEERING AND SMART IDENTIFICATION

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

RESEARCH GROUP FOR MINERAL ENGINEERING AND SMART IDENTIFICATION

RESEARCH CENTER FOR MINERAL TECHNOLOGY

FOCUS

The Mineral Engineering and Smart Identification Research Group focuses on developing automated and intelligent systems for rapid and accurate mineral characterization, as well as mineral engineering for innovative applications across the mineral industry.

1 DATA COLLECTION

A — AERIAL

UAV DRONE IDENTIFICATION



- Multi-Spectral
- Magnetometer
- LiDAR
- RGB Cameras

GIS WORK



- Mapping
- Validation

B — TERRESTRIAL

SUBSURFACE IDENTIFICATION



- Physical Properties

SAMPLING



- Multimethod Identification: XRF, XRD, XRM, SEM, etc.

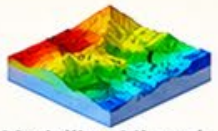
2 DATA PROCESSING



Data Integration / Machine Learning →



Mineral Data Compilation +



Modelling Mineral Data →



Mineral Identification and Characterization

3 OUTPUT

A



Mineral Model →



Mineral Identification and Characterization Module →

B



Data Library of Mineral Identification Based on Mineral Characterization

MINERAL ENGINEERING AND SMART IDENTIFICATION

The Mineral Engineering and Smart Identification Research Group conducts research on the development, utilization, and enhancement of mineral understanding through the integration of smart identification technologies and mineral engineering principles.



UAV DRONE IDENTIFICATION

Conducting airborne data acquisition using various sensors to obtain mineral information through differences in spectral response, color, texture, shape, and other fextures.

GIS WORK

Visualization of spatial distribution differences and mineral potential in 2D and 3D using GIS.





SAMPLING

Obtaining mineral composition values through direct sampling on the surface and subsurface layers.



SUBSURFACE IDENTIFICATION

Identification of mineral composition non-destructively through subsurface characteristics.





BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

RESEARCH GROUP FOR MINERAL ENGINEERING AND SMART IDENTIFICATION

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

RESEARCH GROUP OF THE RESEARCH CENTER FOR MINERAL TECHNOLOGY



Mineral Technology for Rare Earth Elements

(Mineral Technology for Rare Earth Elements)

Prof. Dr. Eng. Widi Astuti

58 Ce Cerium	66 Dy Dysprosium	68 Er Erbium	63 Eu Europium	64 Gd Gadolinium	67 Ho Holmium
57 La Lanthanum	71 Lu Lutetium	60 Nd Neodymium	59 Pr Prasedymium	61 Pm Promethium	62 Sm Samarium
21 Sc Scandium	65 Tb Terbium	69 Tm Thulium	70 Yb Ytterbium	39 Y Yttrium	

RESEARCH MEMBERS

1. Fika Rofiek Mufakhir, S.T., M.T.
2. Dr. Yayat Iman Supriyatna, M.T.
3. Prof. Drs. Samin
4. Ir. Moch. Setyadji, M.T.
5. Suyanti, S.ST., M.Eng.
6. Slamet Sumardi, M.T.
7. Ika Maria Ulfah, S.T., M.T.
8. Dr. Hendra Prasetia, M.Sc.
9. Heru Agung Saputra
10. Muhammad Hafid Masruri, S.Si

DEFINITION

The Mineral Technology for Rare Earth Elements (LTJ) Research Group is a research group focused on the recovery and extraction of rare earth elements (LTJ) from various sources, both primary (mineral ores) and secondary or non-conventional sources (e-waste, spent catalyst, spent battery, spent magnet, red mud from bauxite, and coal fly ash), using various methods such as beneficiation, atmospheric and high-pressure leaching, bioleaching, reduction, roasting, smelting, precipitation, solvent extraction, ion exchange, electrorefining, and electrowinning, as well as combinations of these methods, to produce high-purity rare earth element products that can be applied for various needs and strategic industries.

RESEARCH SCOPE

1. **Rare earth element resources:** from monazite, xenotime, zircon sand, ion adsorption clay (IAC), laterite, red mud from bauxite, spent catalyst, spent battery, petroleum-based spent magnet, coal fly ash, tin tailings, mud from Lapindo, and other mining waste (AAT).
2. **Beneficiation/processing methods:** consisting of gravity separation (jig, tabling), magnetic separation, electrostatic separation, and flotation.
3. **Recovery, extraction and refining methods:** consisting of atmospheric chemical leaching, high-pressure chemical leaching, bioleaching, reduction, roasting, smelting, precipitation, solvent extraction, ion exchange, electrorefining, and electrowinning.
4. **Study on the enhancement of technology scale:** from laboratory scale to pilot plant scale for industrial application and dissemination.
5. **Characterization of rare earth elements and production of rare earth element products:** for potential applications in various needs and industries.

COLLABORATION PARTNERS

SWINBURNE UNIVERSITY OF TECHNOLOGY · Akita University · 九州大学 KYUSHU UNIVERSITY · PennState · UNIVERSITI TEKNOLOGI PETRONAS · UNIVERSITAS INDONESIA · ITERA

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

RARE EARTH ELEMENT RESOURCE POTENTIAL IN INDONESIA

Diverse mineral and non-conventional resources as strategic opportunities for rare earth element (REE) supply



Tin | Ilmenite | Zircon | Monazite | Silica

Bangka Belitung Regency

RESEARCH FOCUS & LOCATIONS

Mamuju Regency, West Sulawesi

Monazite & Xenotime
Primary REE source

Rare Earth Elements: La, Ce, Nd, Pr, Y

Radioactive: U & Th
Source of associated radioactive elements

PRIMARY REE SOURCE

Ion Clay Adsorption
Clay-type REE source in tropical regions

Rare Earth Elements: La, Ce, Nd, Pr, Y

OTHER POTENTIAL SOURCES:

Red Mud (Bauxite Residue)
REE source from alumina industry residue

Coal Fly Ash
REE source from power generation

Lapindo Mud
REE potential from volcanic mud and sediments

E-Waste
REE source from electronic waste

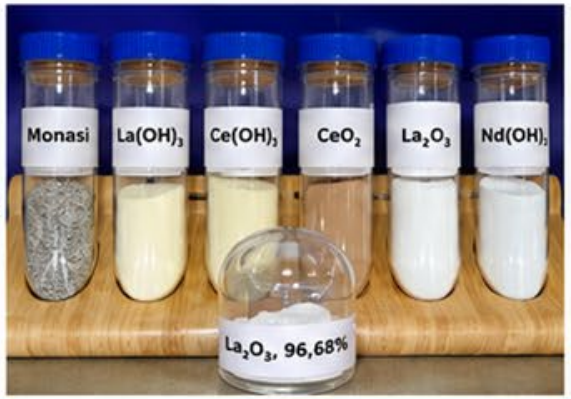
BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

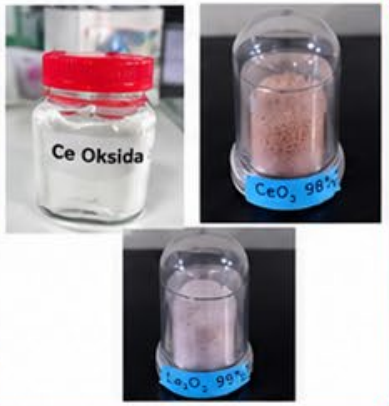
SUMMARY: Rare Earth Element (REE) Mineral Technology Research

Monazite



$(Ce, La, Nd, Pr, Sm\ Th)PO_4$





Ion Adsorption Clay





Xenotime



$(Y, Dy, Yb, Gd, Th)PO_4$ atau YPO_4



Coal Fly Ash



REE Concentrate



Processing Neodymium Oxide to Neodymium Metal Using a Metallothermic Reduction Process.



REE Oxide Concentrate



Nd_2O_3 Pure (Sigma-Aldrich)



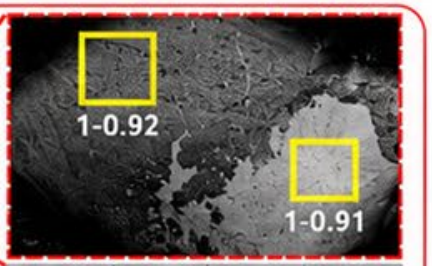
Metallothermic Reduction



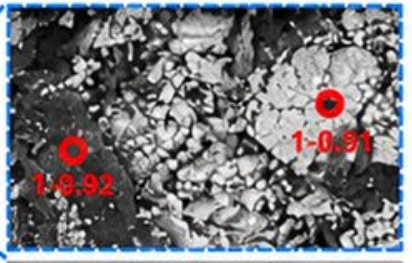
NdPr Metal



Nd Metal



Element	La (%)	Pr (%)	Nd (%)
1-0.91	0.00	89.12	10.88
1-0.92	7.76	79.57	12.67



Element	Nd (%)	Mg (%)
1-0.91	98.18	1.82
1-0.92	2.08	97.92

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

MINERAL TECHNOLOGY RESEARCH CENTER GROUP



Non-Metallic Mineral Technology

(Non-Metallic Mineral Technology)

David Chandra Birawidha, MT



RESEARCH GROUP MEMBERS

1. Evi Dwi Yanti, M.T.
2. Kusno Isnugroho, S.T.
3. Yusup Hendronursito, S.T., M.T.
4. Dr. Amru Daulay, S.Pd., M.Si.
5. Yassaroh, S.Pd., M.Si., Ph.D.
6. Muhammad Amin, S.T.

DEFINITION

This research group focuses on technologies to enhance the added value of non-metallic minerals, ranging from processing technologies to the utilization of mineral research results, including non-metallic minerals such as silicate minerals (quartz, feldspar, kaolin), carbonate minerals (calcite, gypsum, dolomite), industrial minerals (zeolite, bentonite, perlite), and mineral-based research in rocks such as limestone, andesite, granite, and basalt.

SCOPE OF WORK

1. Development of processing technologies for non-metallic minerals and rocks from both primary and secondary sources as functional materials, ceramics, fertilizer, and advanced geopolymer materials.
2. Development of mineral modification technologies for non-metallic minerals and rocks from both primary and secondary sources through beneficiation processes, hydrometallurgy, pyrometallurgy, electrometallurgy, and biometallurgy (biometallurgy).
3. Feasibility analysis and enhancement of research products as preparation for commercialization of the technology.

ITERA
UNIVERSITAS INDONESIA

NON-METALLIC MINERAL TECHNOLOGY RESEARCH GROUP

Synthesis of Silicon and Reduced Graphene

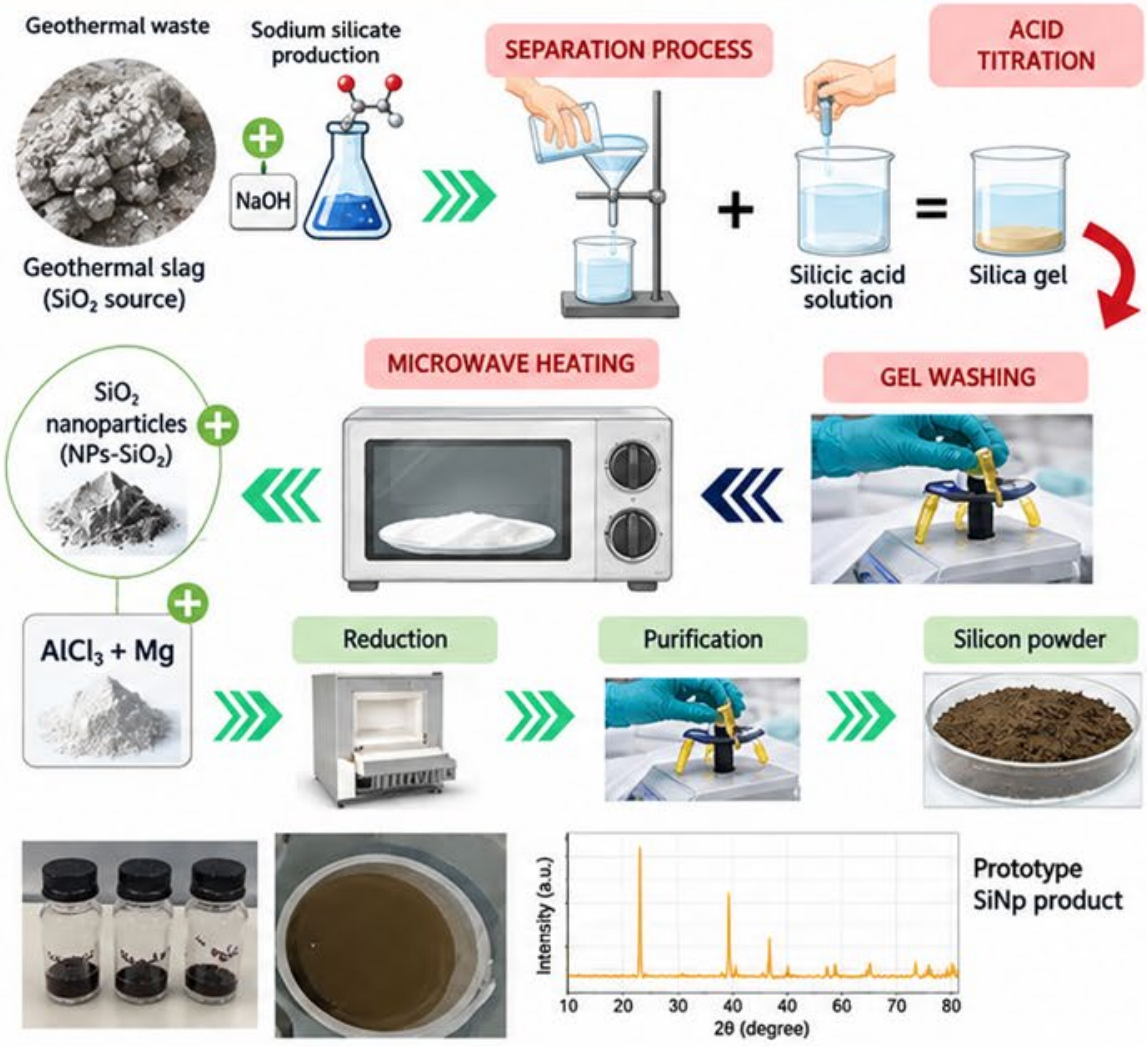


Illustration of geothermal slag synthesis into silicon nanoparticles

Fabrication of Mesoporous Silica for Battery Applications

BRIN NATIONAL RESEARCH AND INNOVATION AGENCY

Mesoporous silica – based materials for various applications



Applications

Nanocarrier
for bioactive compounds encapsulation



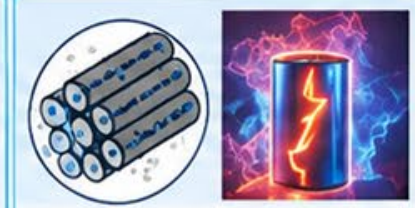
High stability · Controlled release · Biocompatible

Adsorbent
for water pollutants



High adsorption capacity · Recyclable · Environmental friendly

For supercapacitor
(silica-based conductive polymer composite)



High surface area · Improved conductivity · High energy density

NON-METALLIC MINERAL TECHNOLOGY RESEARCH GROUP

Ceramic Production from Local Minerals and Secondary Resources

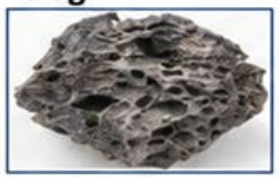
Clay



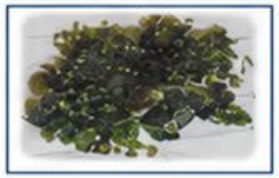
Limestone



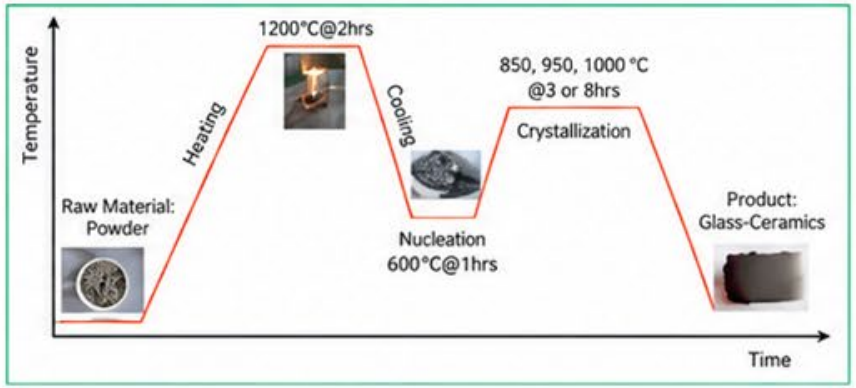
Slag



Basalt



Devitrification: Nucleation & Crystallization

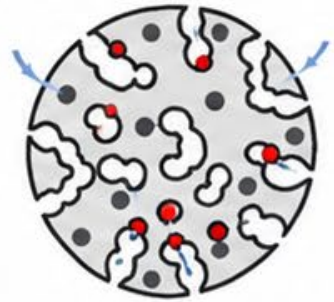


Foam Glass-Ceramics

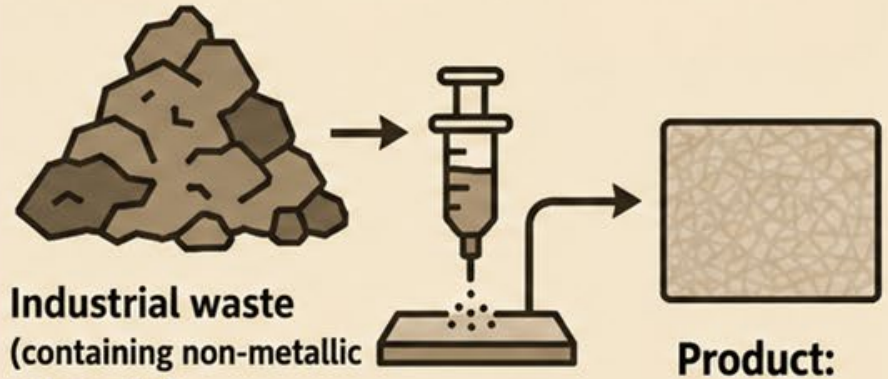


GGC with CaO/MgO doping can capture CO_2 through mineral carbonation reactions, forming stable carbonates and enabling long-term carbon storage with high thermal and structural stability.

CO_2 Capture & Storage



PROCESS: INDUSTRIAL WASTE NANOFIBER (ELECTROSPINNING)



Industrial waste (containing non-metallic minerals)

Product: Nanofiber

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

MINERAL TECHNOLOGY RESEARCH CENTER GROUP



Non-Fuel Utilization of Coal

(Non-Fuel Use of Coal)

Dr. Miftahul Huda

RESEARCH GROUP MEMBERS

1. Dr. Anggoro Tri Mursito, M.Sc.
2. Ir. Suganal
3. Ir. Truman Wijaya
4. Ir. Edwin Akhdiat Daranin, M.Sc.
5. Drs. Firdaus Djabar
6. Asnan Rinovian, S.Si., M.T.
7. Singgih Prabowo, M.T.

DEFINITION

This research group focuses on the non-fuel utilization of coal and the processing of coal and its derivative products into carbon-based materials with higher added value, excluding nano carbon.

SCOPE OF WORK

1. Beneficiation: coal washing, coal upgrading.
2. Coal Processing: carbonization, gasification, production of coke, activated carbon, coal tar pitch, etc.
3. Coal Utilization: adsorbents, fertilizers, etc.

ITERA

Development of Coalite Processing Technology into Artificial Graphite and Pilot-Scale Anode Sheet



Artificial Graphite

Synthetic graphite produced from amorphous carbon using the following processes:

1. High-temperature graphitization
2. Catalytic pyrolysis
3. Hot isostatic pressing (HIP)
4. CVD from hydrocarbon at high temperature

Advantages of Artificial Graphite (AG) compared to Natural Graphite:

1. Better cycling stability
2. Faster charging performance
3. Higher and more consistent quality



Anode Sheet

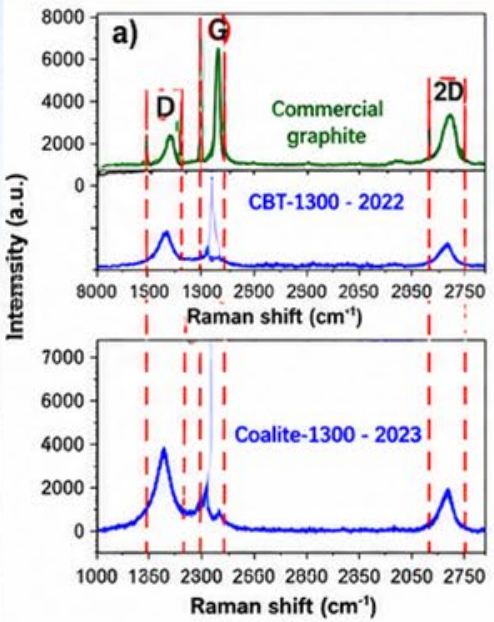
Green Product

An electrode in the form of a sheet made from a copper foil coated with graphite carbon on both sides, used as an anode for Li-ion batteries.

This product is a **Green Product** because it uses a water-based formulation.

Quantitative XRD Analysis of AG

Lorentzian Function	Sample	2 theta (deg)	theta (deg)	d-spacing (Å)	DoG (%)	FWHM (deg)	Lc (Å)	n
Graphite C002	CBT-1300	26.56	13.28	3.36	96.87	0.19	425.39	126.73



Raman results indicate a higher peak intensity compared to commercial graphite.

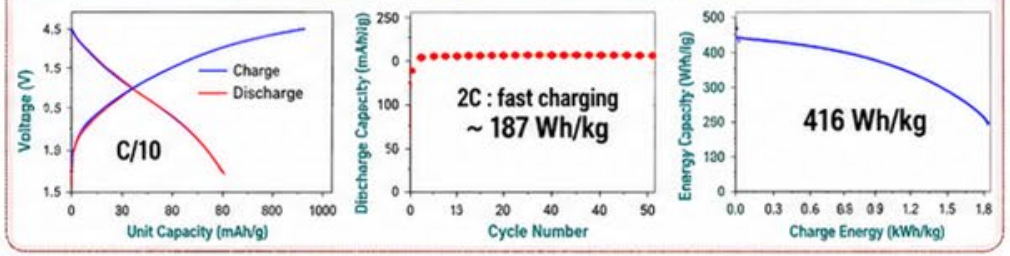
This indicates a good graphitization level, which is supported by CV test results showing a low oxidation peak voltage of around **0.3 V.**

Raman analysis results of AG

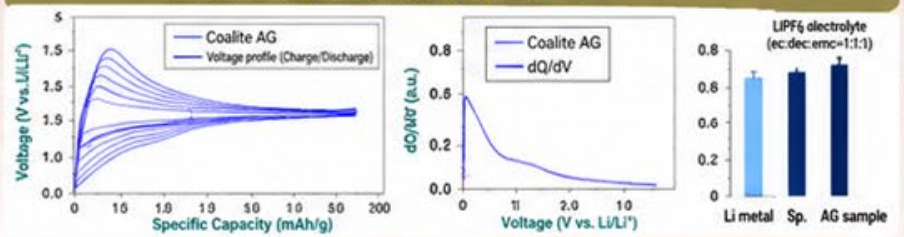
Diversification of Coalite Products



Coin Cell Test of Coalite AG : Full Cell

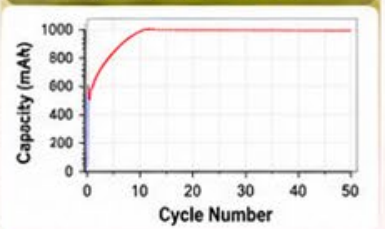


Coin Cell Test of Coalite AG : Half Cell



Charge Capacity Test

Charge capacity = **913 mAh**



Ultrahigh Capacity Charging Performance

~100 mAh, 4 units, total capacity 99,000 mAh



KEY HIGHLIGHTS

- Artificial Graphite (AG) from PTBA has a graphite structure suitability up to **96.8%.**
- The first discharge capacity of AG PTBA reaches **478 mAh/g** (half cell), which is higher than commercial MCMB, which only achieves **372 mAh/g.**
- Full-cell coin cell test (AG vs. LiNMC) shows an energy density of **416 Wh/kg** (0.1C). At 2C, it can reach **187 Wh/kg** (45%).
- The average capacity of 18650-type cells produced is **1200–500 mAh.** The variation is mainly due to non-optimal slurry preparation, coating process, and assembly stage.
- Other results from the fast charging test (2C) show an energy of **187 Wh/kg** after 50 cycles with a normal discharging capability up to **400 Wh/kg.**

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

MINERAL TECHNOLOGY RESEARCH CENTER GROUP

Non-Fuel Use of Coal R&D Group

Research Theme: Development of an Efficient Process for Producing Activated Carbon from Coal

Background:

- Abundant coal resources
- Need to increase coal added value
- Potentially limited use of coal as a fuel in the future



Coal → Carbonization → Char → Catalytic Activation → Activated Carbon with High Surface Area

Catalyst → Catalytic Activation

Steam → Catalytic Activation





Experimental Equipment and Products

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

MINERAL TECHNOLOGY RESEARCH CENTER GROUP



Mineral Processing Impact Management
(Mineral Processing Impact Management)

Dr. Adji Kawigraha

Research Group Members

1. Abdul Hapid, S.T., M.Eng.
2. Nur Vita Permatasari, S.Si., M.Ling.
3. Ir. Haswi Purwandanu Soewoto
4. Yeni Novitasari, S.T.
5. Ika Monika, S.Si
6. Dr. Ir. Nurhadi Wibowo., MT., IPM., ASEAN Eng.
7. Ir Retno Wijayanti, MAB
8. Dra. Sri Handayani, M.Sc.
9. Ir. Sariman
10. Dr. Della Kharisma, M.Si
11. Nur Ikhwani, M.T.
12. Ridha Cindra Oktian, S.T.
13. Irwan Haryanto, S.T., M.T.

DEFINITION

Mineral processing impact management refers to activities to place, control, and utilize by-products in solid and liquid forms generated from mineral processing activities in an environmentally sound and value-added manner.



SCOPE OF WORK

1. Technologies related to the **utilization of solid (SHP and SHPP) and liquid by-products** from large- and small-scale mineral processing activities.
2. Technologies for the **placement and control** of solid (SHP and SHPP) and liquid by-products from large- and small-scale mineral processing activities.
3. Technologies for the **utilization of electronic waste** as a substitute material from natural resources.
4. Technologies for the **stabilization/immobilization of heavy metals and pollutants** from mineral processing activities.
5. Technologies for the **recovery of metals** from solid and liquid streams generated by mineral processing activities.
6. **Examples of by-products** include SHP and SHPP from nickel and bauxite processing, tailings from gold processing, nickel slag, asphalt concrete processing by-products, and mercury-containing by-products.

PARTNERS (2025)

Institut Teknologi Sepuluh Nopember (ITS)
Universitas Indonesia
IPB University
Universitas Diponegoro
HARTA
SWINBURNE
MASSEY University
THE UNIVERSITY OF AUCKLAND
University of New Zealand
antam

Potential Collaborators

KOMIR
Institute of Institute of Development Studies
Ministry of Environment and Forestry (KLHK)
University of Exeter
UNDP

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

Bauxite Processing Residues: From Waste to Value-Added Products

Bauxite Residue (Red Mud)



ANTAM

Challenges

- Requires large land area for disposal
- Air pollution (dust)
- Water pollution (leachate)

1 Gas Adsorbent Production



Pretreatment
(drying, grinding, activation)



Mixing
(with additives)



CO_2 Mixing
(carbonation)



Mixing



Waste Gas Adsorbent
(e.g., CO_2, SO_2, NO_x)

APPLICATION
- CO_2 capture
- Flue gas treatment
- Air pollution control

2 Sponge Iron and Nugget Production



Biomass
(e.g., rice husk, wood waste)



Mixing
(homogenization)



Pelletization



Microwave heating



Sponge Iron & Nugget
(Fe-rich product)

APPLICATION
- Iron making
- Alternative raw material for steel
- Value-added metal recovery

3 Adsorbent Production



Chemical activation
(alkali/acid treatment)



Drying
(oven)



Sieving and drying



Adsorbent

APPLICATION
- Heavy metal removal (Pb, Cd, Cr, etc.)
- Dye/Coloring agent removal from wastewater

4 Growth Media Production



Pretreatment
(drying, grinding)



Additive
(e.g., organic material, soil conditioner)



Mixing
(homogenization)



Medium Pressure Processing



Growth Media
(for plant cultivation)

APPLICATION
- Revegetation and land rehabilitation
- Soil amendment

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

New developing green extraction of critical mineral for energy security in Indonesia

Research Center of Mineral Technology

Research Group of Mineral Technology on Base and Precious Metal





BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

MINERAL TECHNOLOGY RESEARCH CENTER GROUP

Next



Mineral Technology of Base and Precious Metals

(Mineral Technology of Base and Precious Metals)

Dr. Fathan Bahfie, M.Si



Research Group Members

1. Anton Sapto Handoko, S.T., M.T.
2. Drs. Harta Haryadi
3. Ir. Herry Poernomo, M.T.
4. Ir. Muzakky, M.Si.
5. Dr. Sudibyo, S.T., M.Sc.
6. Ir. Suharto, M.T.
7. Ulin Herlina, M.T.
8. Dr. Fajar Nurjaman, MT

DEFINITION

The Mineral Technology of Base and Precious Metals focuses on technologies for the processing and extraction of base and precious metal minerals into high-value-added products.

Base Metal Commodities:

Iron, Aluminum, Tin, Tungsten, Molybdenum, Tantalum, Cobalt, Bismuth, Cadmium, Titanium, Zirconium, Antimony, Manganese, Beryllium, Chromium, Germanium, Vanadium, Gallium, Hafnium, Indium, Niobium, Rhenium, and Thallium.



Precious Metal Commodities:

Ruthenium, Rhodium, Palladium, Silver, Osmium, Iridium, Platinum, and Gold.



RESEARCH SCOPE

1. Development and strengthening of technologies for the processing of base and precious metal mineral resources through characterization, beneficiation, and extraction.
2. Conducting techno-economic and market chain feasibility studies for base and precious metal commodities.

COLLABORATING PARTNERS

UNIVERSITAS INDONESIA

integra

ITERA

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

MINERAL TECHNOLOGY RESEARCH GROUP
BASE AND PRECIOUS METALS

Ferroalloys Production (FeNi, FeMn, FeCr)

Smelter Issues



- **High cost investment**
- **Low grade ores**
- **High energy consumption**
- **High temperature operation**
- Energy availability
- Environmental impact
- Tailing & slag utilization

Low Investment Smelting Process
(using Hot Blast Cupola Furnace)



Nickel Ore
1.8 Ni–27.5 Fe–1.2 Cr
25.84 SiO_2–11.1 MgO



Scale up into 3 ton of NPI/day
Hot Blast Temperature: 300–350 °C
Tap to tap time: 2.5 – 3 hours



Nickel Pig Iron (NPI)
2.5 C – 8.44 Ni – 0.03 Si – 0.01 Mn – 0.073 Cr

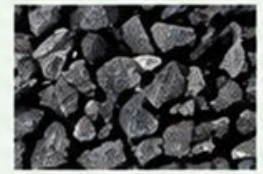


Slag

Smelting of Nickel Ore with Biomass as Reductant
(using Submerged Arc Melting Furnace)



Agglomerated Nickel Laterite Ores



Charcoal of biomass as reductant



Flux (Limestone)







High temperature process : 1500 – 1600 °C

Submerged Arc Furnace:
- 3 Phase SAF, with 3 Electrodes
- 250 kVA, 60 volt, up to 1500 Ampere
- Capacity : 100 Kg ores/heat

Applications and Benefits

- Production of ferroalloys (FeNi, FeMn, FeCr)
- Utilization of low grade ores
- Use of biomass as reductant
- Lower investment cost
- Reduced environmental impact
- Tailing and slag utilization

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

MINERAL TECHNOLOGY RESEARCH GROUP – BASE AND PRECIOUS METALS

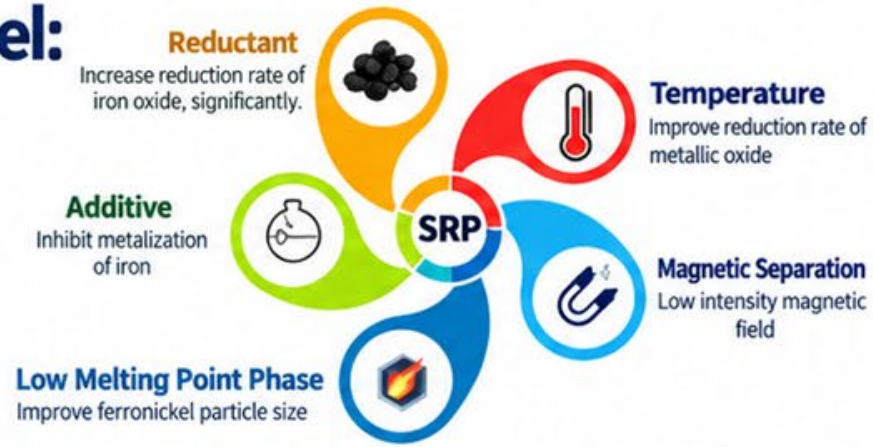
Processing of Laterite Nickel Ore into Ferronickel: Selective Reduction Method



Selective Reduction Process:

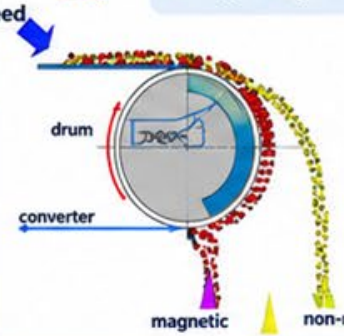
- Moderate temperature process
- Low-cost energy (compared with BF Smelter)
- Various reductant can be used (no-cokes required)
- High Ni-grade in ferronickel





Reduction Process

$NiO + CO\ (g) \rightarrow Ni + CO_2\ (g)$
$C + CO_2\ (g) \rightarrow 2CO\ (g)$
$3Fe_2O_3 + CO\ (g) \rightarrow 2Fe_3O_4 + CO_2\ (g)$
$Fe_3O_4 + CO\ (g) \rightarrow 3FeO + CO_2\ (g)$
$FeO + CO\ (g) \rightarrow Fe + CO_2\ (g)$
$1/4\ Fe_3O_4 + CO\ (g) \rightarrow 3/4\ Fe + CO_2\ (g)$



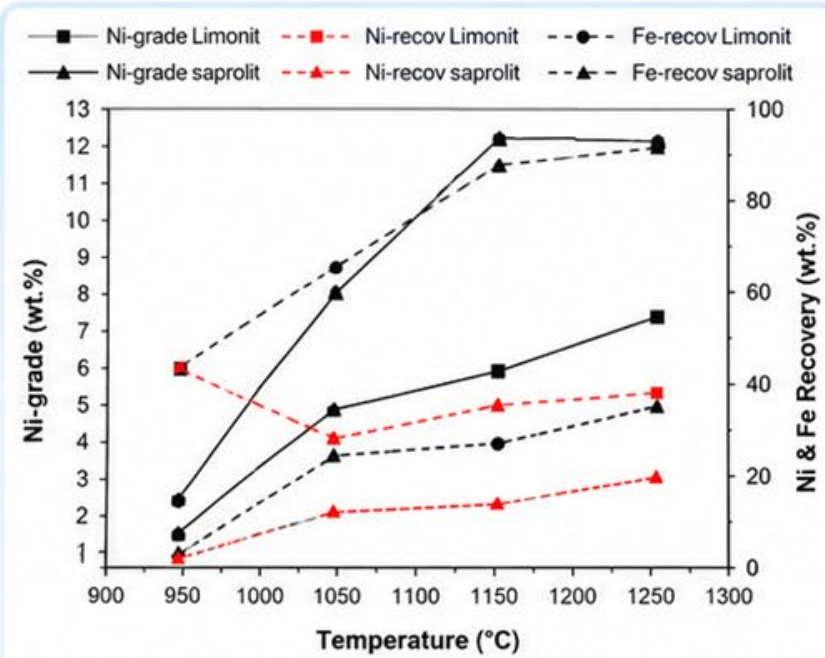
Fine NPI (Concentrate)

Selective Reduction Process:

$1/4\ Na_2SO_4 + CO\ (g) \rightarrow 1/4\ Na_2S + CO_2\ (g)$
$Na_2S + FeO + 2SiO_2 \rightarrow Na_2SiO_3 + FeS$

Impurities – $MgSiO_3$, FeO, FeS (Tailings)

PT. Trimetal Indonesia

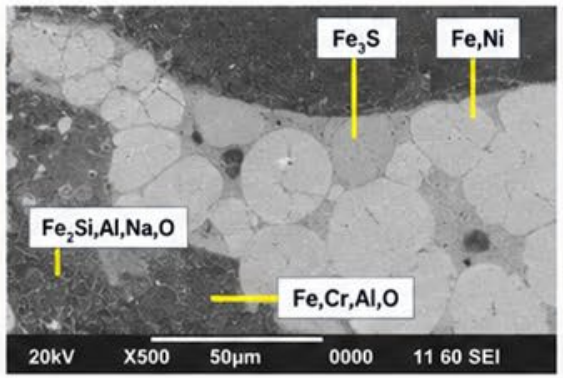






Scale Up into 3 ton of NPI/day
Hot Blast Temperature: 300–350 °C
Tap to tap time: 2.5 – 3 hours





Reduction of Saprolite & Limonite

Hydrophobic Deep Eutectic Solvent Extraction of Ni-Co from Laterite

On Developing

1. Background

1. Cobalt: a critical metal for clean energy



Li-ion batteries (NMC, NCA) | Electric vehicles | Renewable energy storage

Rising demand, supply chain risks, and environmental concerns require more sustainable extraction approaches.

2. Laterite ores as cobalt resources



Saprolite
(higher Ni, lower Fe)

Co: 0.07 mass%
Ni: 2.10 mass%
Fe: 38.28 mass%

Limonite
(lower Ni, higher Fe)

Co: 0.03 mass%
Ni: 1.81 mass%
Fe: 67.35 mass%

3. Challenges of conventional leaching

- High acid consumption
- Poor selectivity
- Extensive co-dissolution of Fe, Al, Mg, Mn, and Si
- High energy consumption and equipment corrosion

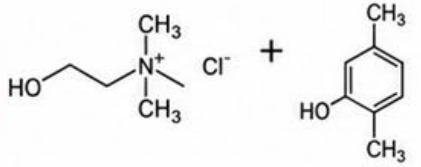
This study: Hydrophobic DES activated with acetic acid for selective cobalt extraction from saprolite and limonite under mild conditions.

2. Methods

A. Hydrophobic DES preparation

Choline chloride
13.962 g

Thymol
60.088 g



Molar ratio 1:4
(choline chloride : thymol)

80 °C, 300 rpm, 1 h



Hydrophobic DES
(homogeneous liquid)

B. Acetic-acid activation and leaching



100 mL hydrophobic DES + 200 mL acetic acid
30 °C, 300 rpm, 1 h

500 mg laterite ore (10 mL DES solution)
60 or 70 °C
3, 6, or 9 h
300 rpm

Centrifugation
5000 rpm, 50 min

Pregnant leach solution (Co analysis)

Leaching residue (SEM/EDX, elemental mapping)

C. Characterization and analysis



AAS
(Co concentration)

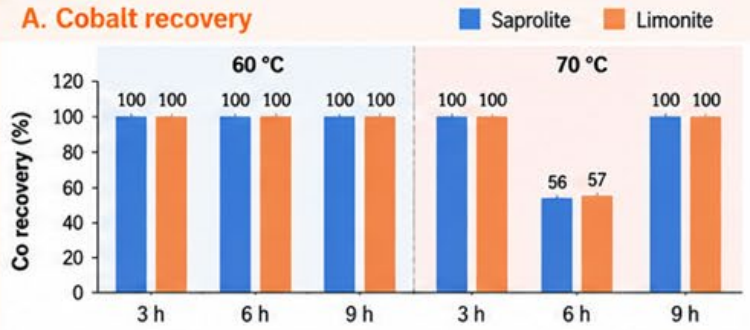
FTIR
(Solvent interactions)

Synchrotron
Co/Mn K-edge XANES/EXAFS
(Oxidation state & local structure)

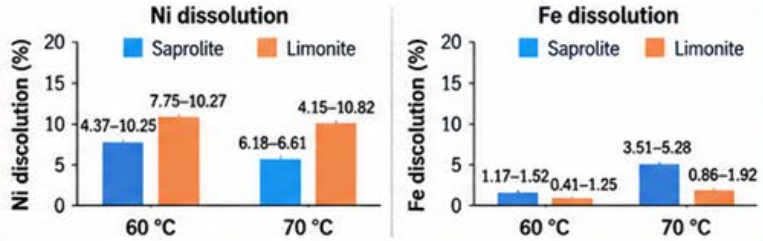
FE-SEM/EDX
(Morphology & elemental mapping)

3. Results

A. Cobalt recovery



B. Selectivity (dissolution of other metals)



C. Cobalt in leachate (visual appearance and concentration)



Pregnant leach solutions
(after leaching at 60 °C, 6 h)

Sample	Co concentration (in leachate, % recovery)
Limonite (LLa)	100%
Saprolite (LSa)	100%

Acetic acid-activated choline chloride–thymol hydrophobic DES enables highly selective cobalt extraction from saprolite and limonite, achieving 100% Co recovery at 60 °C with limited Ni (4.15–10.82%) and Fe (0.41–5.28%) dissolution.

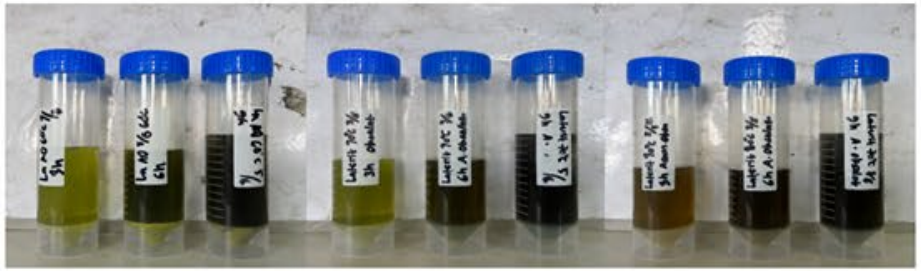
Iron Extraction Using Oxalic Acid and DES-Deep Eutectic Solvent (ChCl:Oxalic Acid)

On Developing

❖ Why Laterite?



❖ Visual Appearance of Laterite Leachates OX



❖ Visual Appearance of Laterite Leachates DES

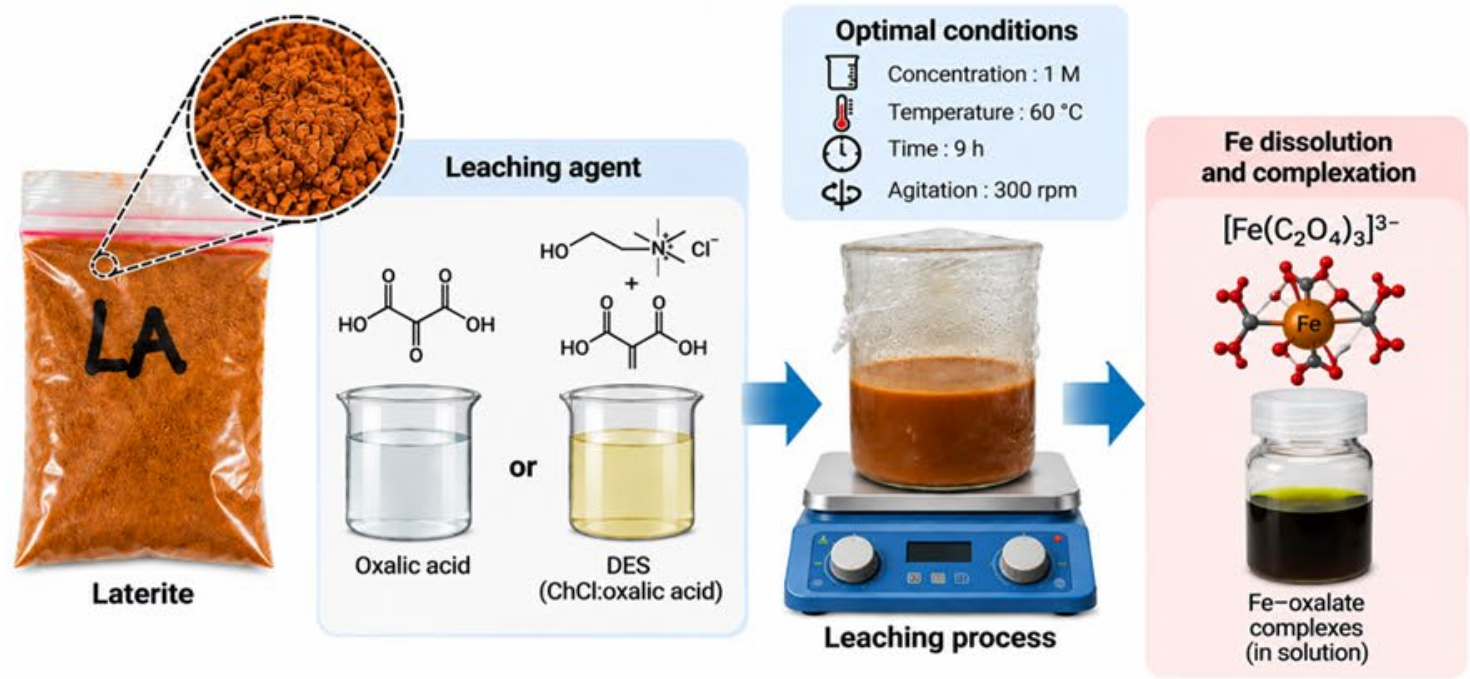


❖ The Optimum Percentage of Fe Recovery

Table 1. Extraction of Fe from Laterite using DES (ChCl:asam oksalat) and Oxalic Acid.

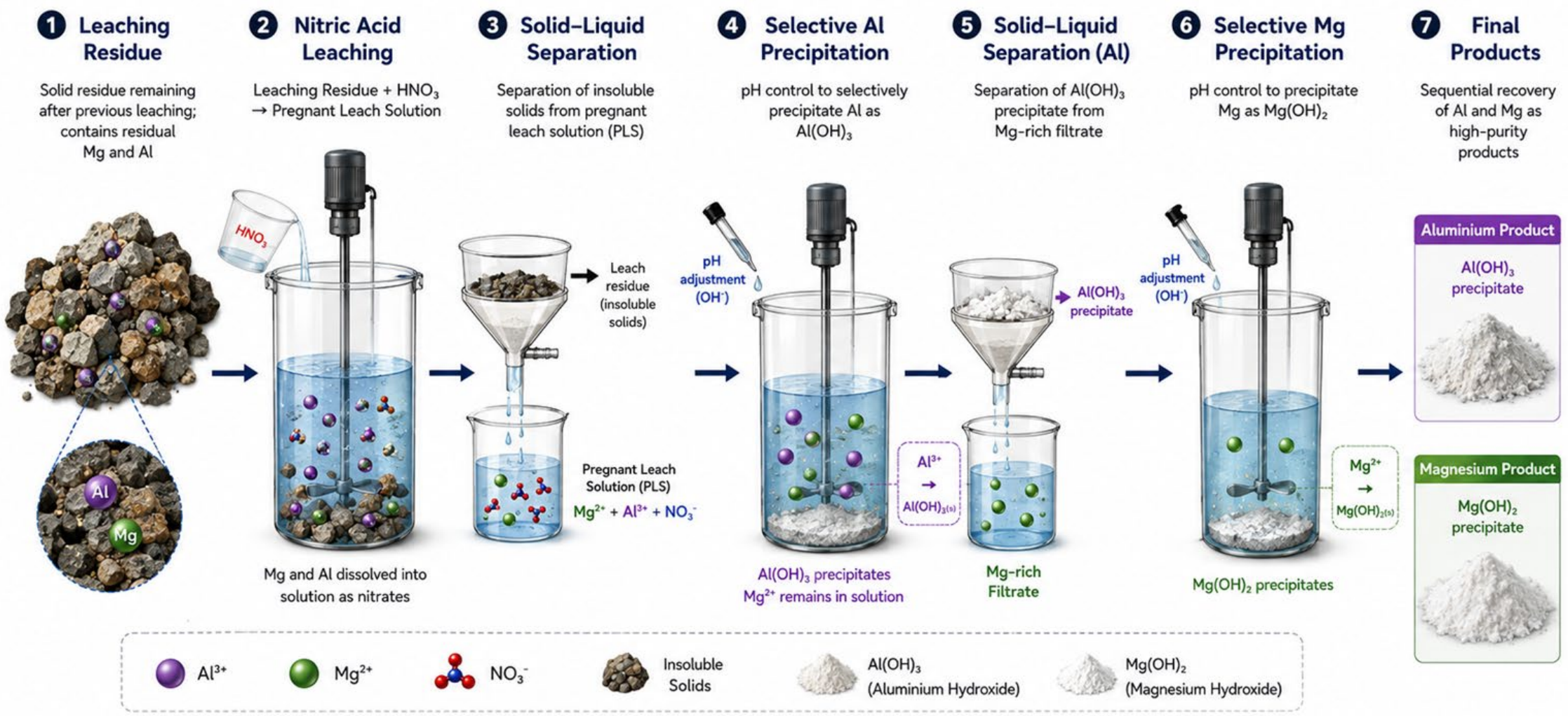
Solvent	[Fe] (ppm)	[Ni] (ppm)	[Mg] (ppm)	Rec Fe (%)	Rec Ni (%)	Rec Mg (%)
Oxalic Acid	1.6241	0.0993	0.0337	51.27	100	16.9
DES	1.7082	0.2004	0.023	53.93	100	11.75

❖ The Pathway for Fe Dissolution and Oxalate Complexation from Laterite



Magnesium and aluminium extraction

On Designing



Sequential Recovery and Separation of Aluminium and Magnesium from Leaching Residue using Nitric Acid

- Efficient dissolution of Mg and Al
- Selective precipitation for high-purity products
- Sustainable and environmentally friendly process
- Value recovery from secondary resources

SUSTAINABLE INDUSTRIAL PROCESSING OF LATERITE ORE

A CIRCULAR ECONOMY & ZERO-WASTE PATHWAY

CIRCULAR ECONOMY

ZERO WASTE



LATERITE ORE

TYPICAL COMPOSITION (wt%)

Fe_2O_3	20 – 40%
NiO	1 – 2.5%
CoO	0.05 – 0.2%
MnO	0.5 – 2%
MgO	10 – 20%
Al_2O_3	10 – 25%
SiO_2	20 – 50%
Others	< 5%

STAGE 1 IRON RECOVERY

PROCESS

Selective leaching using oxalic acid



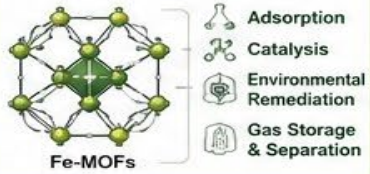
TARGET METAL

Fe

Iron (Fe)

END-USE APPLICATION

Iron used as precursor for synthesis of Fe-based MOFs



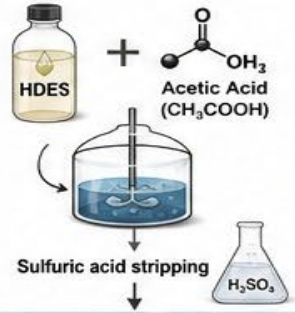
Removes dominant iron fraction and enhances downstream metal recovery

IRON-DEPLETED RESIDUE

STAGE 2 CRITICAL BATTERY METALS RECOVERY

PROCESS

Selective leaching using HDES–acetic acid

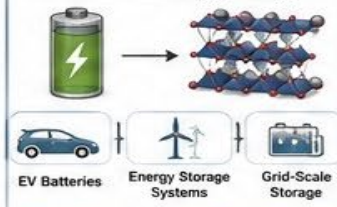


TARGET METALS

Ni Nickel · Co Cobalt · Mn Manganese

END-USE APPLICATION

Critical raw materials for lithium-ion battery cathode materials & energy storage



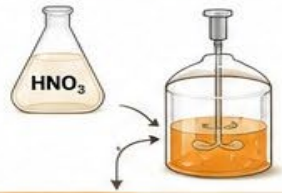
High recovery of Ni, Co, Mn using selective, recyclable green solvent and efficient stripping

BATTERY-METAL-DEPLETED RESIDUE

STAGE 3 MAGNESIUM & ALUMINUM RECOVERY

PROCESS

Selective leaching using nitric acid



TARGET METALS

Mg Magnesium · Al Aluminum

END-USE APPLICATION

Lightweight metals for transportation (automotive & aerospace) and biomedical applications



- High strength-to-weight ratio
- Corrosion resistance
- Biocompatibility

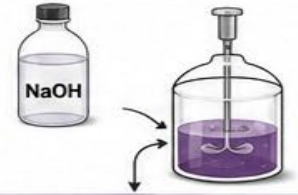
Recovers valuable light metals from residual mineral fractions for high-value applications

RESIDUAL SILICATE MATRIX

STAGE 4 SILICON RECOVERY

PROCESS

Silicon recovery using sodium hydroxide (NaOH) treatment



TARGET METALLOID

Si

Silicon (Si)

END-USE APPLICATION

High-purity silicon for photovoltaic (solar panel) technologies



Converts final residue into valuable silicon for clean energy technologies

INTEGRATED CIRCULAR FLOW & RESOURCE EFFICIENCY

Sequential & selective recovery of all major valuable constituents → Maximum resource efficiency through complete utilization of laterite ore → Near-zero waste generation → Recyclable reagents & minimized environmental impact → High-value product diversification for sustainable industries → Supports circular economy and green materials manufacturing

EVERY COMPONENT OF LATERITE ORE RECOVERED AND CONVERTED INTO HIGH-VALUE PRODUCTS

- Resource Efficiency
- Waste Minimization
- Sustainable Utilization
- Green Industrial Value

TOWARDS A GREEN FUTURE

LEGEND

Leaching Process · Stripping/ Recovery · Metal Recovery · Downstream Application · Circular Economy · Environmental Benefit

On Developing

Hydrophobic Deep Eutectic Solvent Extraction of Mn-Ni-Co from Reused Battery

1. BACKGROUND

Growing LiB use → increasing waste



Valuable metals in LiB waste (XRF)



Mn	27.06%
Ni	8.60%
Co	3.01%
Fe	2.19%
Cu	0.83%
Al	1.05%
Si	0.23%
S	0.17%
Ca	0.13%

(XRF)

Problem with conventional hydrometallurgy



- Uses corrosive mineral acids
- May generate hazardous wastewater

Hydrophobic Deep Eutectic Solvent (HDES) as an alternative

- More environmentally friendly
- Hydrophobic (immiscible with water)
- Can form a two-phase system
- Potential to facilitate metal extraction and phase separation

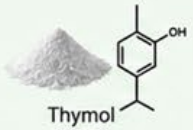
Research objective

- Evaluate the effect of HDES:acetic acid ratio, temperature, and leaching time on Ni and Co extraction
- Analyze morphology and elemental distribution using FESEM-EDS

2. METHODS

Materials


Choline chloride ($CHCl_3$) (HBA)


Thymol (HBD)


CH_3COOH (acetic acid)

H_2SO_4
H_2O_2
distilled water

1. HDES preparation

60.088 g thymol
+ 13.962 g CHCl



80 °C, 1 h (stirring)

Stand for 24 h

2. Acetic-acid loading

HDES : CH_3COOH (volume ratio)

1:1 (10 mL : 10 mL)
1:2 (15 mL : 30 mL)
2:1 (20 mL : 10 mL)



300 rpm, 35 °C, 1 h

3. Leaching experiment

0.500 g LiB waste
+ 10 mL loaded HDES



Temperature: 60 °C and 70 °C
Time: 3, 6, 9, 12, 18, 24 h
Stirring: 300 rpm

Centrifugation 5 min



4. Characterization and analysis



Metal recovery calculation

$$\text{Recovery (\%)} = \frac{W_2}{W_1} \times 100$$

W_1 : initial metal mass
W_2 : metal mass after leaching

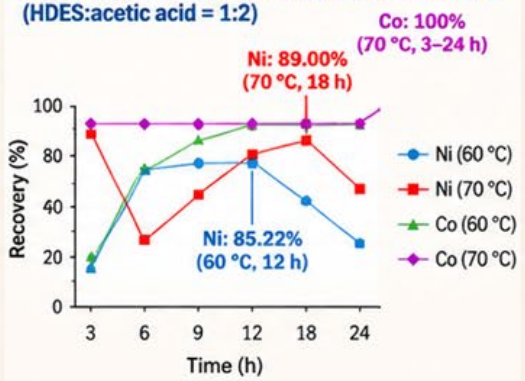
3. RESULTS

Leachate after Ni–Co extraction

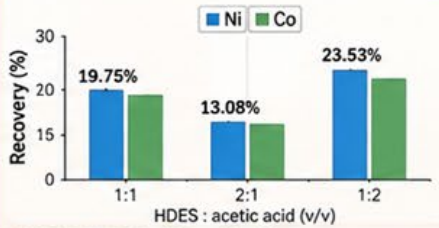


Ni and Co in leachate (AAS)
Ni : 89.00%
Co : 100.00%
(70 °C, 18 h; 1:2 ratio)

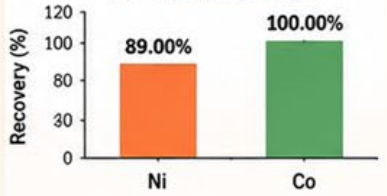
Effect of temperature and time on metal recovery (HDES:acetic acid = 1:2)



Effect of HDES:acetic acid ratio on metal recovery

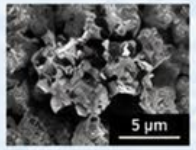


Maximum recovery at optimum condition (70 °C, 18 h; 1:2 ratio)



FESEM-EDS (solid residue)

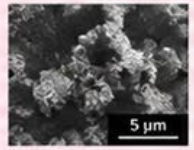
60 °C, 12 h (1:2 ratio)



- Irregular particles
- Rough surface
- Pores/gaps

Elements: C, O, Cl, Ni, Mn.

70 °C, 18 h (1:2 ratio)



- Irregular particles
- Pores/gaps
- Smaller fragments

Elements: C, O, Cl, Ni, Co.

HDES is effective for improving Ni and Co recovery from LiB waste and has potential as a more environmentally friendly extraction method.

Three-Stage Sustainable and Zero-Waste Recycling of Lithium-Ion Battery Waste

HDES-Based Selective Recovery of Critical Metals and Carbon for Circular Battery Supply Chain

Spent Li-ion Battery Waste



Discharged, Dismantled & Shredded

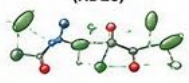
Black Mass (Cathode Materials)

STAGE 1
Selective Recovery of Ni, Co, and Mn

Selective Leaching with HDES–Acetic Acid



Hydrophobic Deep Eutectic Solvent (HDES)



Acetic Acid (HBA/HBD)



Leached Solution (Ni, Co, Mn in HDES)



Sulfuric Acid Stripping



Aqueous Stripping

Ni Co Mn

$NiSO_4$ $CoSO_4$ $MnSO_4$



Residual Solid

- ✓ Selective extraction of Ni, Co, Mn
- ✓ High selectivity, low acid consumption
- ✓ Minimal co-dissolution of Li and Al

STAGE 2
Selective Recovery of Lithium

Selective Leaching with HDES–Formic Acid



Hydrophobic Deep Eutectic Solvent (HDES)



Formic Acid (HBA/HBD)



Leached Solution (Li in HDES)

Back-Extraction / Precipitation



Li^+

Li_2CO_3 / LiOH

Battery-Grade Lithium Compounds

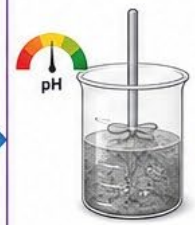


Spent Residue

- ✓ Selective recovery of Li
- ✓ Minimal dissolution of Al, Si
- ✓ Efficient back-extraction and purification

STAGE 3
Carbon Residue Valorization

Neutralization



pH

Drying & Carbon Recovery





Recovered Carbon Material

- ✓ Neutralization to remove residual acidity
- ✓ Drying and recovery of carbon
- ✓ Zero solid waste through valorization

Reintegration into the EV Battery Manufacturing Supply Chain

CIRCULAR ECONOMY

Ni — Nickel Sulfate ($NiSO_4$): Used for Ni-rich cathode synthesis

Co — Cobalt Sulfate ($CoSO_4$): Used for cathode active materials

Mn — Manganese Sulfate ($MnSO_4$): Used for cathode stabilization

Li — Lithium Carbonate / Lithium Hydroxide: Used for lithium salt production

Recovered Carbon (Conductive Carbon): Used as conductive additive in electrodes



Cathode Active Material Production



Cell Manufacturing (Module/Pack)



EV Application

Resource Circularity
Reduces dependence on virgin critical raw materials

Sustainable Metallurgy
Lower environmental footprint and energy consumption

Critical Metal Recovery
High-value recovery of Ni, Co, Mn, Li and carbon

Zero-Waste Battery Recycling
Complete valorization of all process residues

Key Advantages

- Selective & efficient recovery
- Environmentally benign HDES systems
- Low emissions & minimal secondary waste
- Scalable & industrially viable process

Quaternary ammonium cation (HBA) · Hydrogen bond donor (HBD) · Hydrophobic interaction domain

HBA: Hydrogen Bond Acceptor **HBD:** Hydrogen Bond Donor **HDES:** Hydrophobic Deep Eutectic Solvent

Hydrothermal and KOH-Assisted Modification of Brown Coal

for Sustainable Ethylene Adsorption and Extended Fruit Shelf Life

1 Raw Brown Coal



Naturally occurring brown coal with mineral impurities

2 Cleaning



Removes soil, clay, ash and other impurities

Water washing

3 Sizing





Uniform particle size (1–3 mm)

4 Hydrothermal Treatment



Structural modification and pore development

Water

5 KOH Activation



Intimate mixing and activation

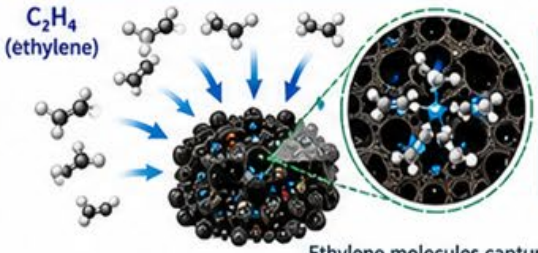
KOH

6 Activated Brown Coal Ethylene Adsorbent



Highly porous structure with abundant adsorption sites

7 Ethylene Adsorption



Ethylene molecules captured in pores

- ✓ High surface area
- ✓ Porous structure
- ✓ Active adsorption sites

8 Postharvest Application



Storage with activated brown coal



Key Outcomes



Reduced Ethylene Concentration | Delayed Ripening | Extended Shelf Life

SUSTAINABLE SOLUTION
Low-cost brown coal resource

CIRCULAR ECONOMY
Waste/resource valorization

REDUCED FOOD LOSS
Preserves quality and value

ENVIRONMENTALLY FRIENDLY
Green technology

Cleaner Planet Healthier Food Future

Thank You..

- Research Centre for Mineral Technology BRIN Kawasan Sains Iskandar Zulkarnain, Jl. Ir. Sutami KM. 15, Tanjung Bintang
- 0811-1933-3617
- prtpm@brin.go.id
- @prtpm_brin
- https://brin.go.id/ornm/prtpm

