

# Our Journey with Particles

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NTNU

The IKP-75 years Jubilee Seminar, NTNU

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Liyuan Deng  
Professor



Tore-Haug Warberg  
Associate Professor



Magne Hillestad  
Professor



Jana P. Jakobsen  
Professor



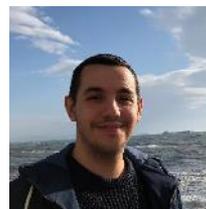
Hanna K. Knuutila  
Professor &  
Deputy of Education



Størker T. Moe  
Associate Professor



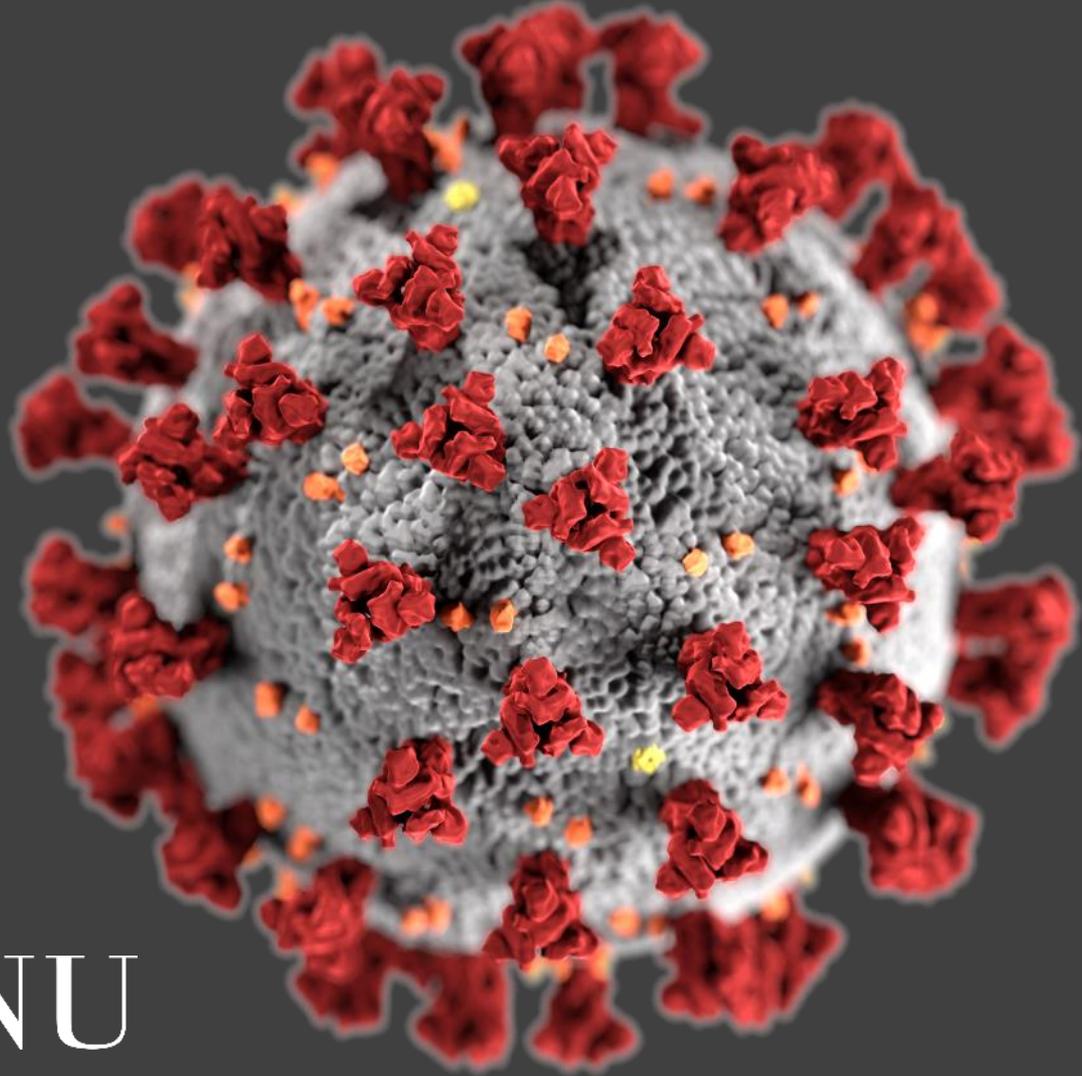
Jannike Solsvik  
Professor



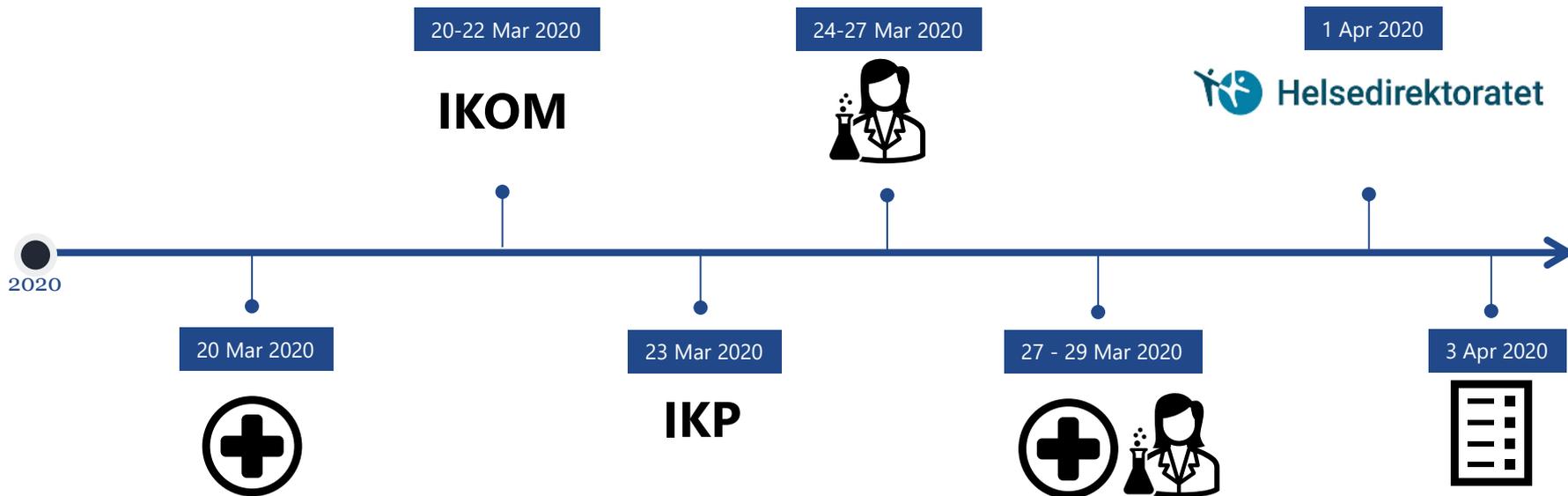
Suat Canberk Ozan  
Adjunct Professor



Hallvard F. Svendsen  
Professor Emeritus



# Our Journey



# Production

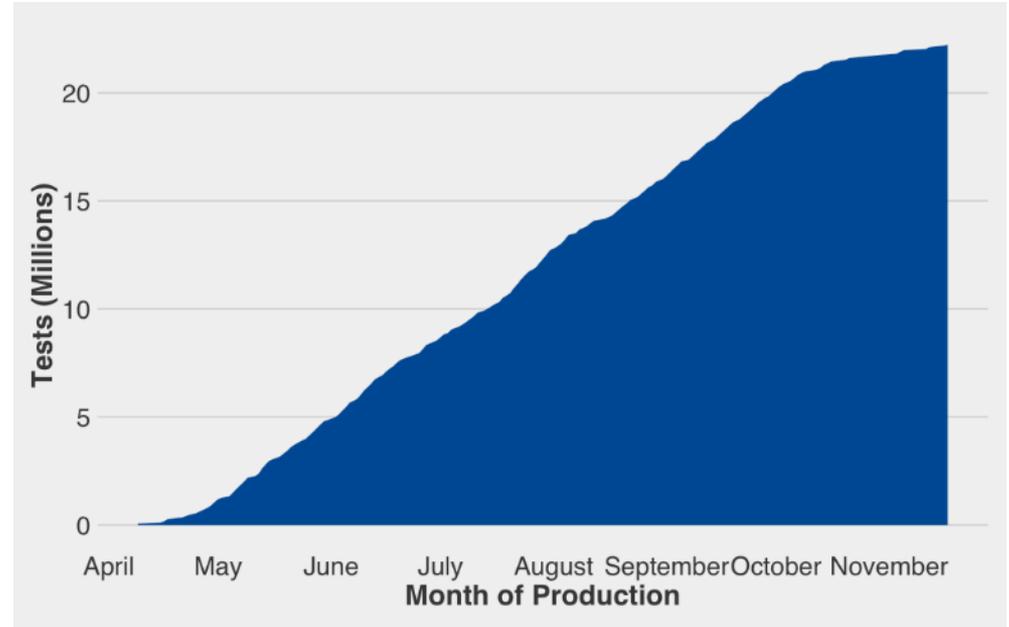
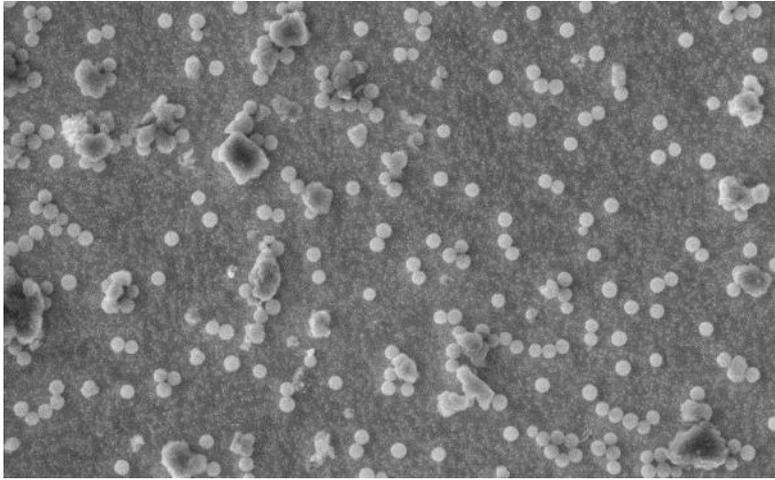
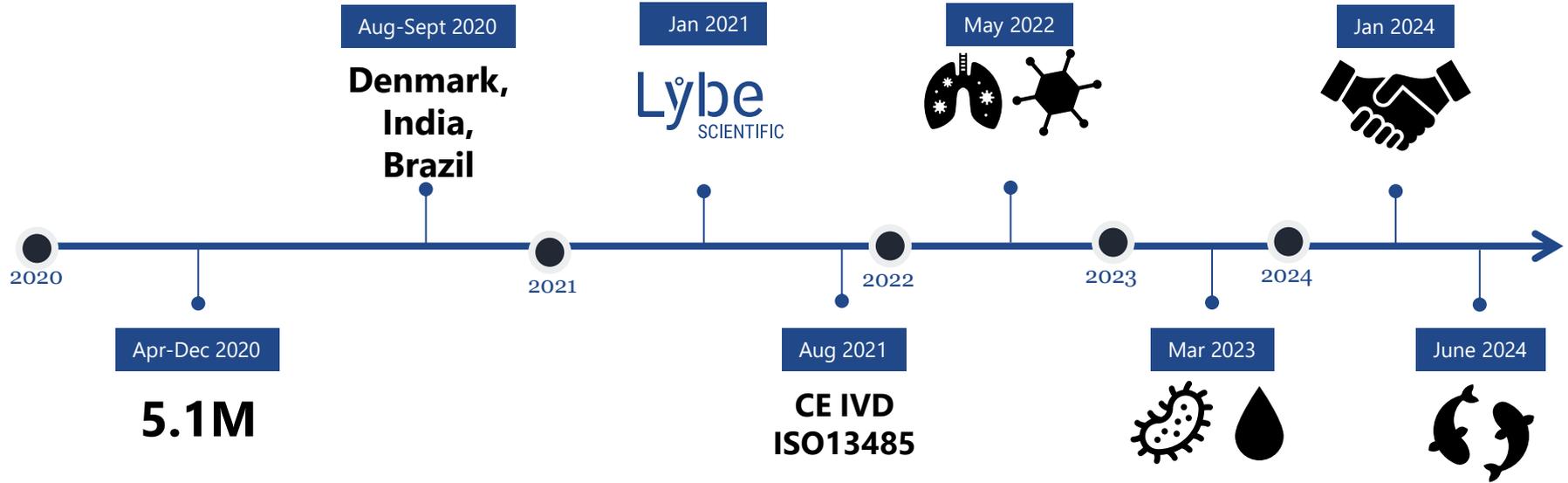




Photo: Geir Mogen

# Our Journey



A blurred, high-angle photograph of a person's face, likely a woman, looking upwards. The image is out of focus, with soft, glowing light effects around the subject's head, set against a dark blue background.

 NTNU



# Researchers Magnar Bjørås and Sulalit Bandyopadhyay at NTNU win The Research Council Innovation Award 2021

[Read more \(in Norwegian only\)](#)



## INNOVATOR OF THE YEAR IKP AND NV'S CORONA TEST INVENTORS



# Disse ansatte får pris ved NTNU

Syv ulike interne priser deles ut ved NTNU, feiringa utsettes.



# Corona Team



Team at Department of Chemical Engineering (IKP)



Team at Department of Clinical and Molecular Medicine (IKOM)

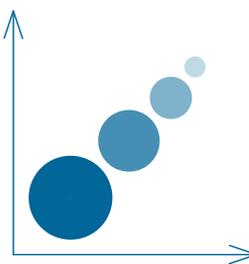
Team at NTNU Technology Transfer A/S (TTO)



# Lybe

SCIENTIFIC

PARTICLE  
ENGINEERING  
CORE FACILITY



PARTICLE  
ENGINEERING  
CENTRE

# Thematic Areas

APPLICATION BASED  
RESEARCH

## NANOMEDICINE

Biosensing  
Diagnostics  
Drug delivery & Therapeutics  
Imaging

## HYDROMETALLURGY AND RECIRCULATION OF BATTERIES

Re-Use of Batteries  
Dismantling & Pre-treatment  
Black Mass Processing  
Process Streams to Products

## ENVIRONMENTAL APPLICATIONS

Water Management  
CO<sub>2</sub> Capture  
Antifouling  
Photocatalysis

FUNDAMENTAL  
RESEARCH



PARTICLE DESIGN

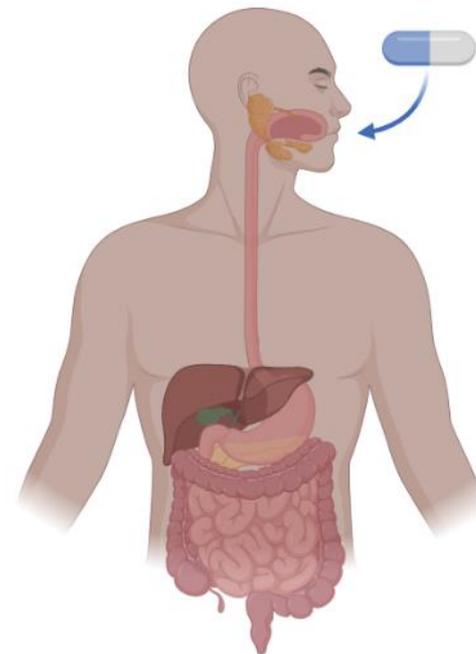
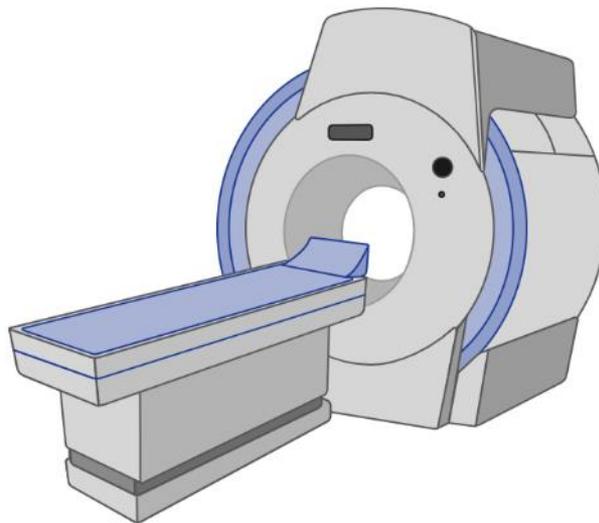
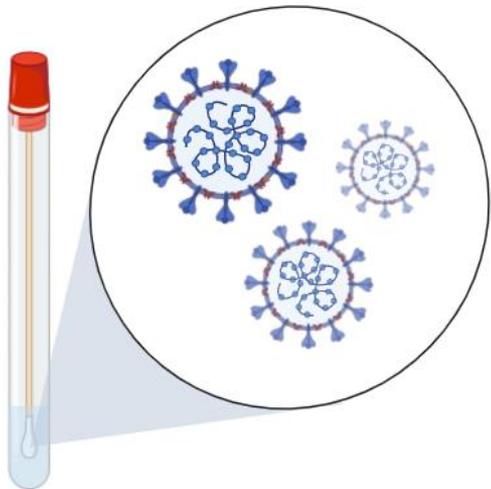


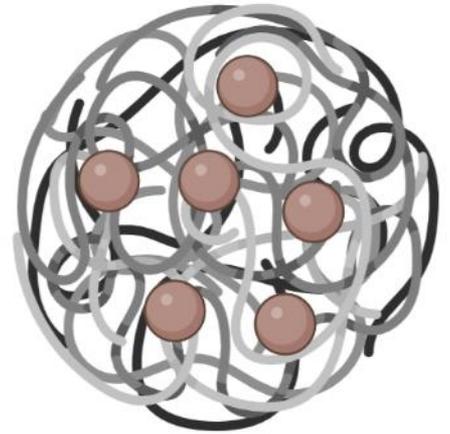
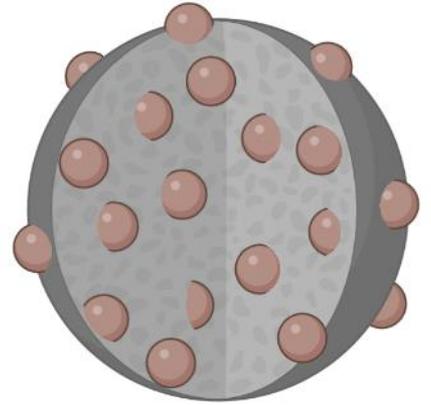
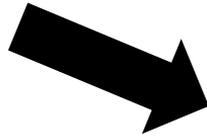
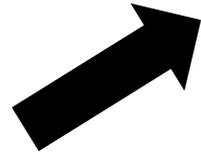
PARTICLE CHARACTERIZATION



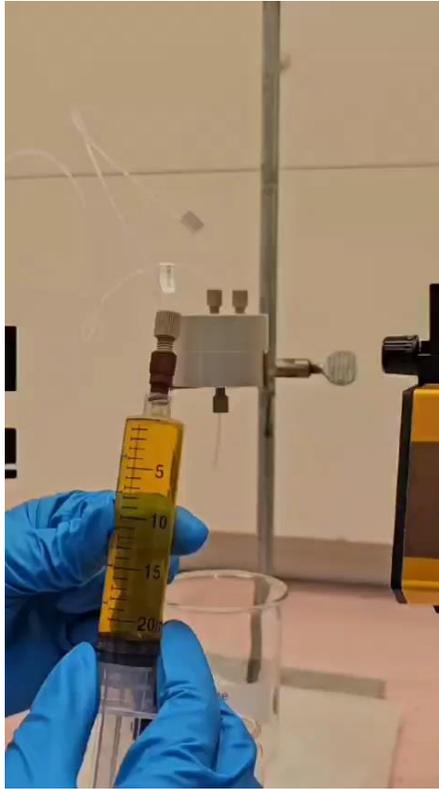
# Particle Engineering Centre – Spring 2024







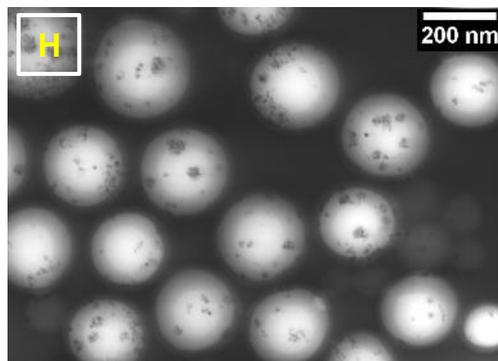
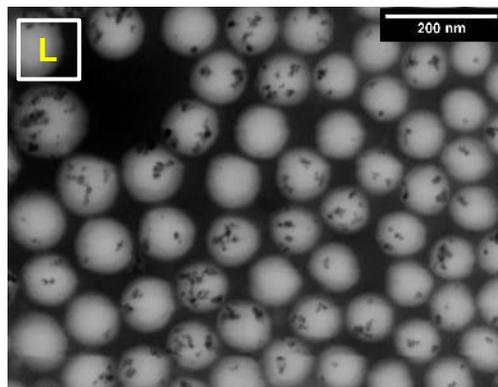
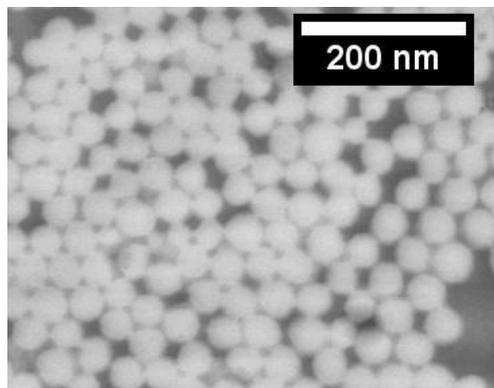
# Flash Nanoprecipitation Method



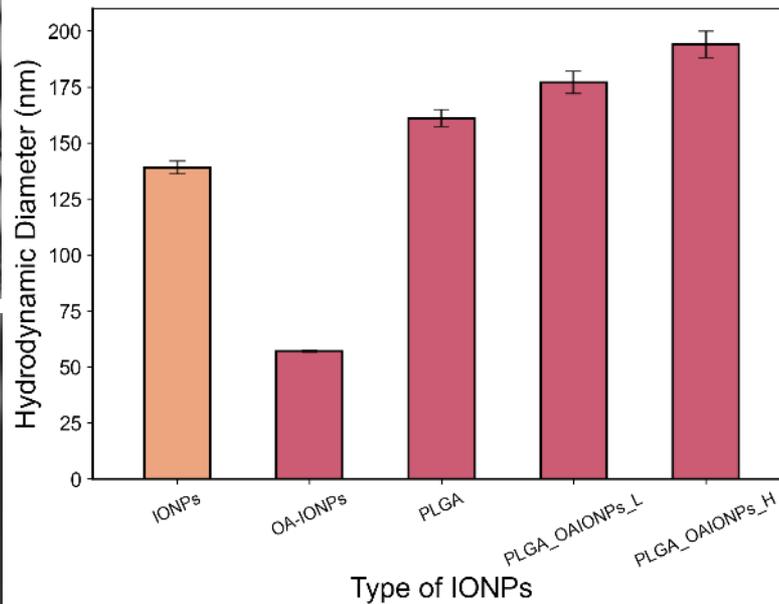
- Organic Stream
  - Oleic acid coated IONPs (OA-IONPs)
  - Poly lactic-co-glycolic acid (PLGA)
  - Tetrahydrofuran (THF)
- Aqueous Stream
  - Water
  - Tween 80

# PLGA-encapsulated IONPs

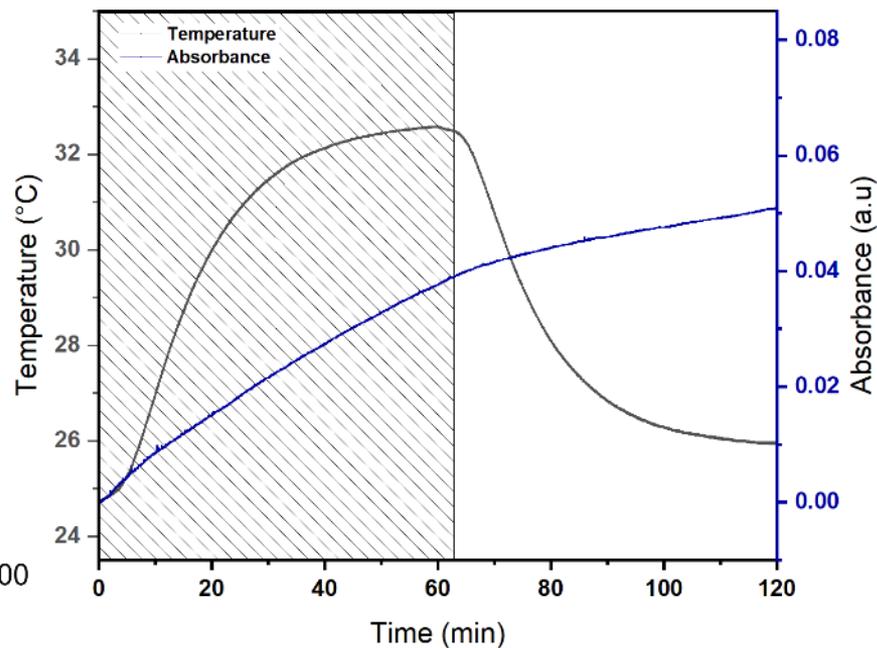
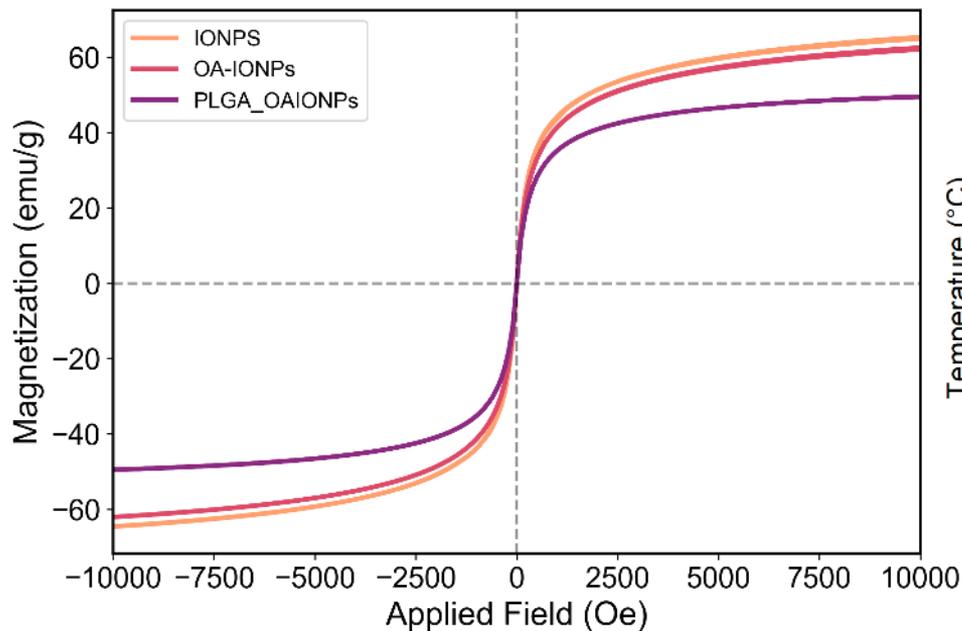
Bare PNPs



PLGA\_OAIONPS

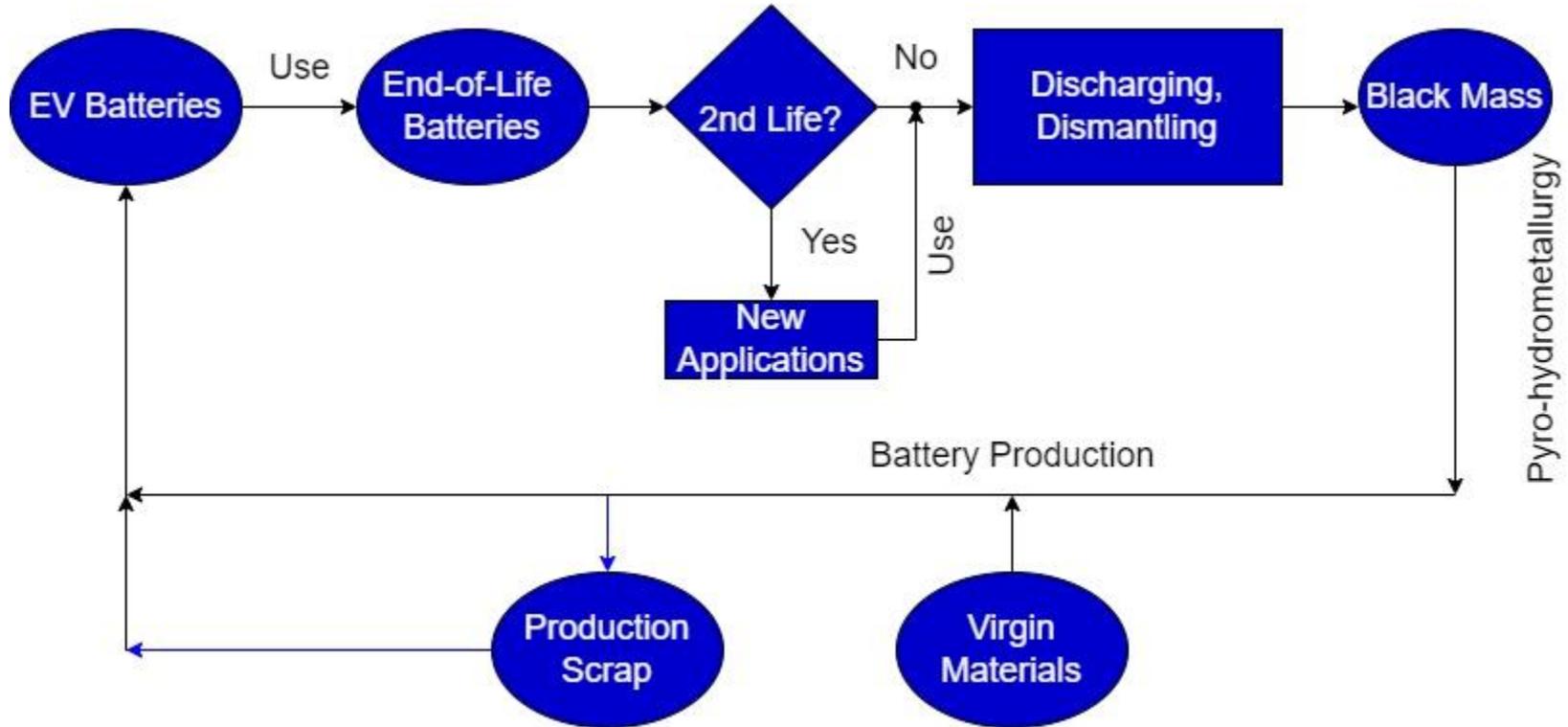


# Magnetically Controlled Drug Release





- Scarcity of resources – unequal world distributions.
- Li recovery from used LIBs – less environmental impacts.
- Co reserves – ethical and environmental concerns.

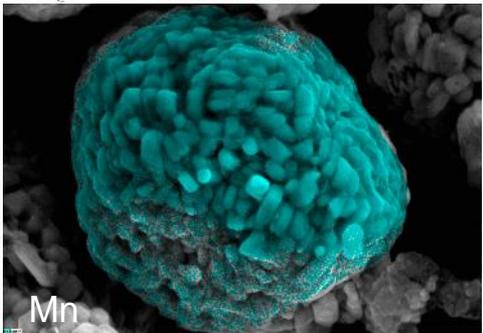
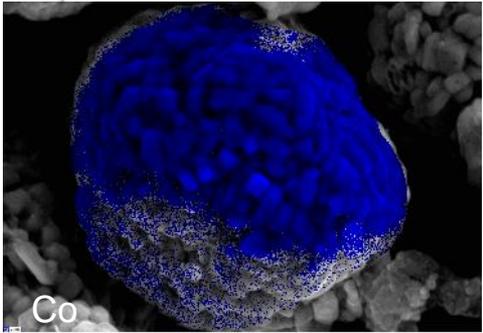
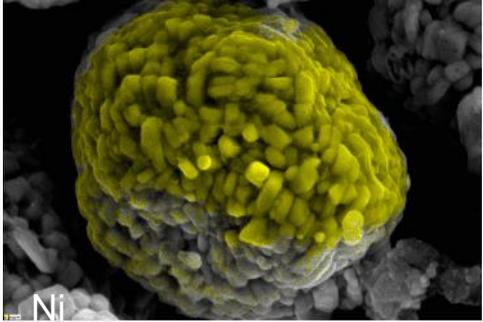
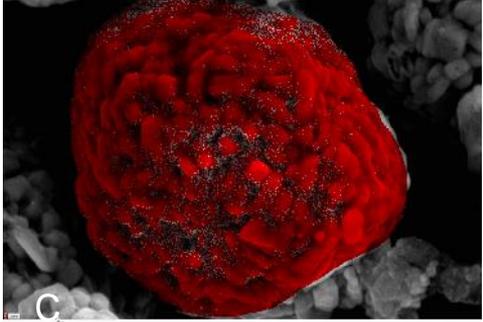
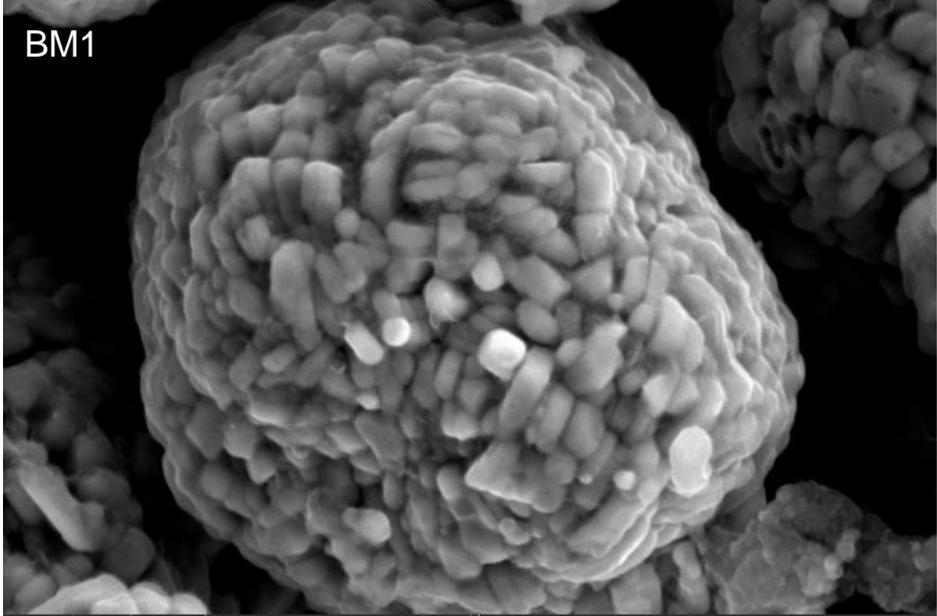


# Industrial Black Mass

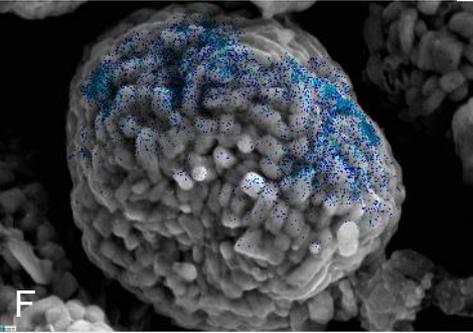
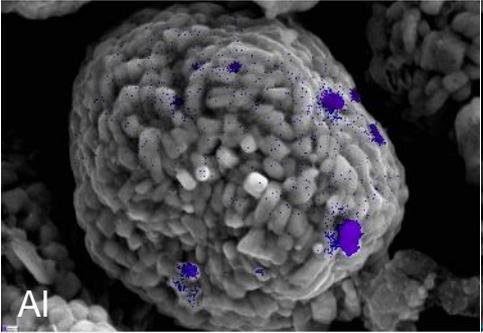
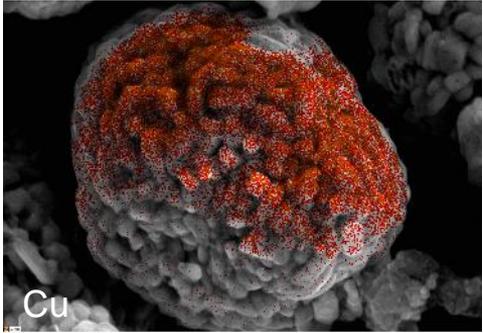
LIBRES IPN Project (2018 – 2022)  
hydrovolt



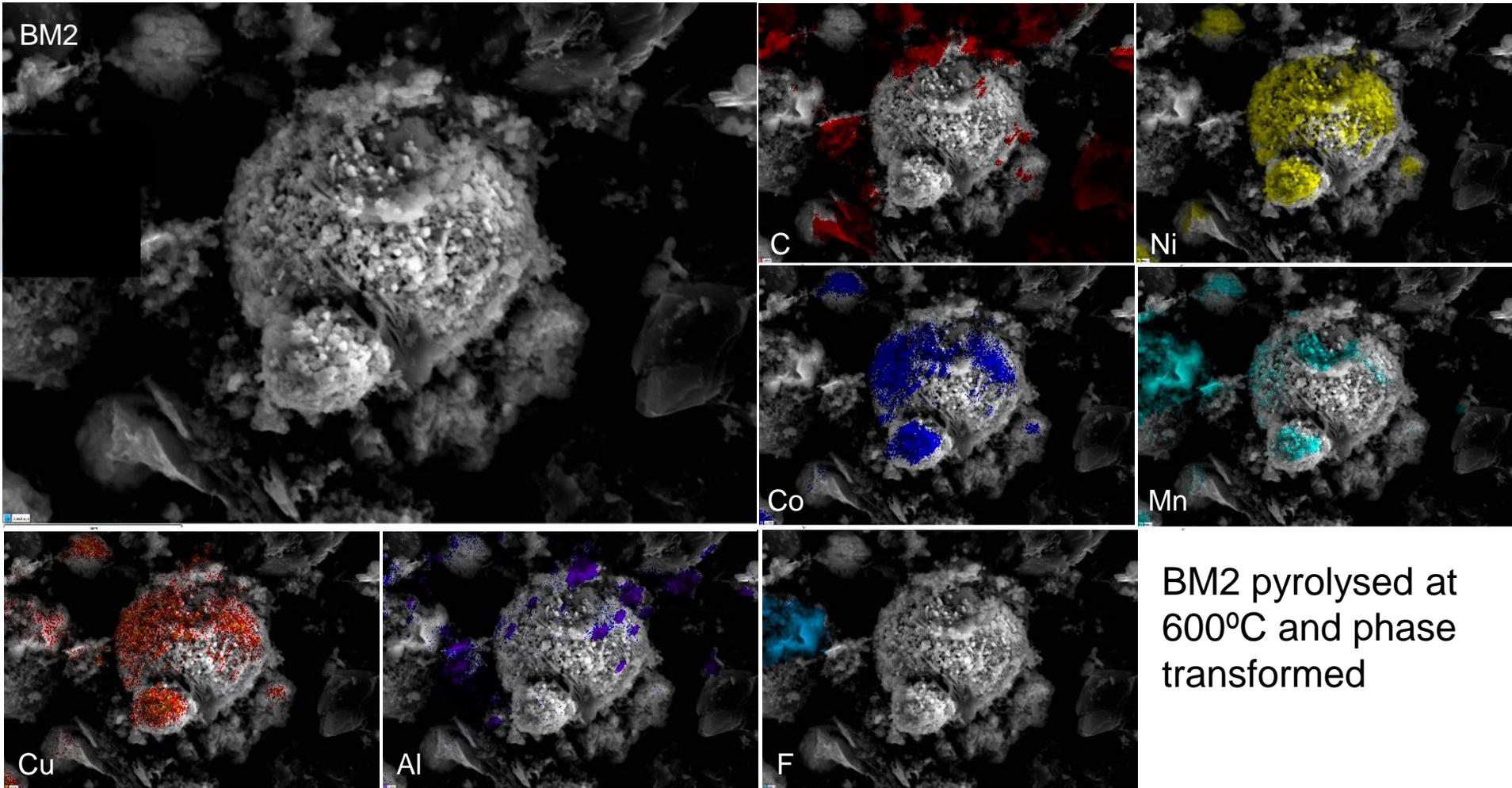
BM1



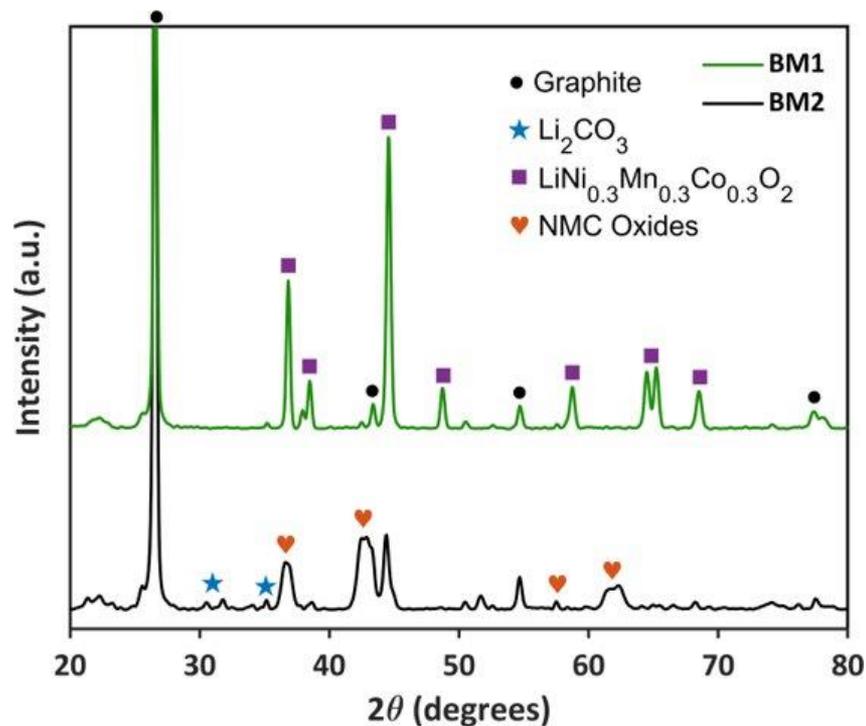
FW	curr	HV	tilt	det	mode	mag	WD
10.4 μm	3.2 nA	10.00 kV	0.0 °	ETD	SE	20 000 x	3.9 mm
							5 μm
NorFab / NTNU NanoLab							



BM1 dried at 150-200°C show needle like structure on NMC particles

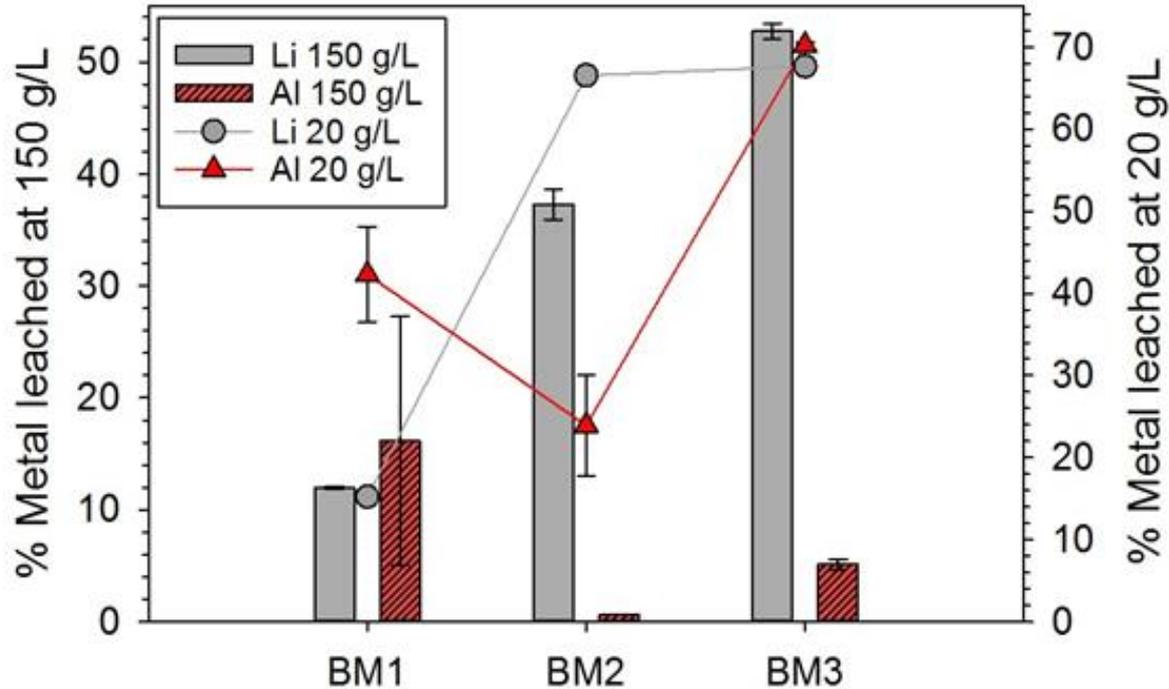


# BM Composition



Metal	BM1	BM2
Li	3.55±0.13	3.85±0.02
Ni	10.17±0.14	11.54±0.15
Mn	8.02±0.18	9.14±0.08
Co	9.73±0.1	11.66±0.11
Cu	1.72±0.01	1.5±0.16
Al	0.15±.01	0.47±0.014

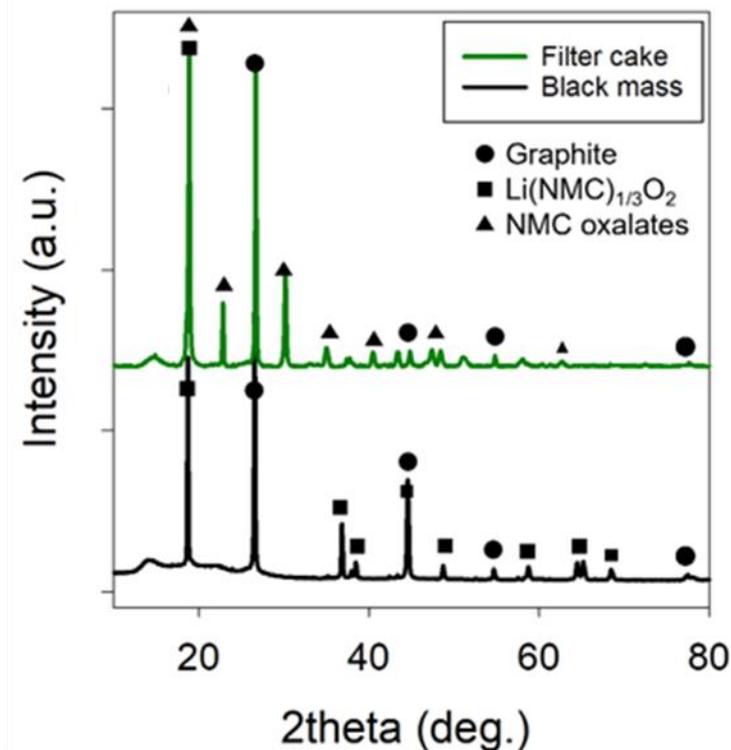
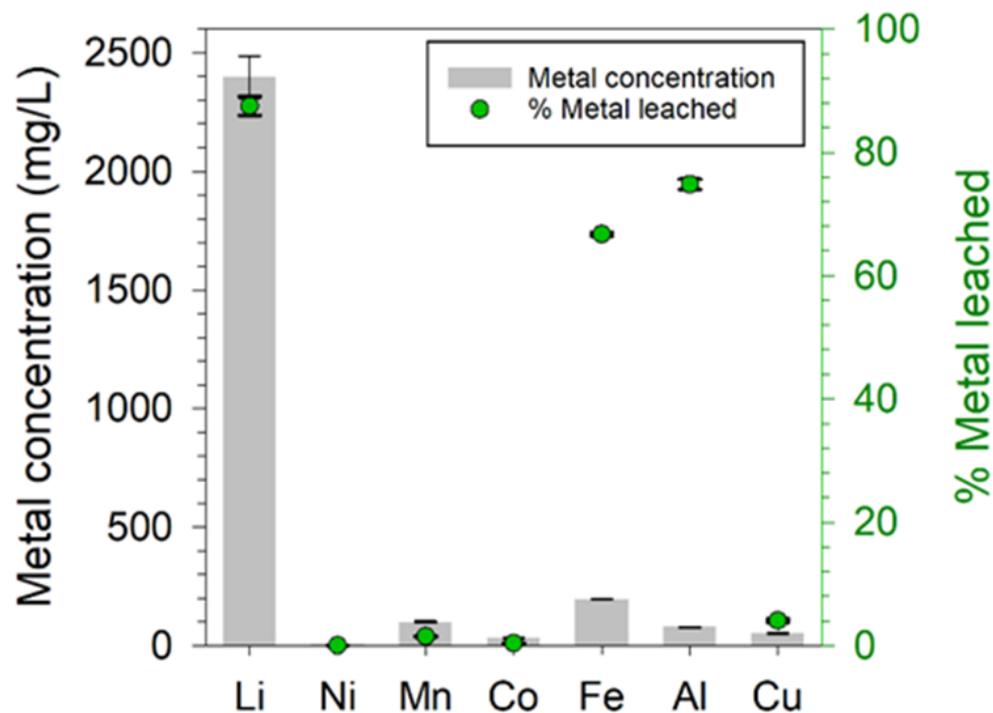
# Selective Li Extraction



- BM1 leaches ~2% of NMC along with Al, Cu & Li giving pH ~5
- BM2 only leaches Li & Al giving pH ~11.5

# Oxalic Acid Leaching

Leaching Conditions: 55°C, 60 mins, 1M oxalic acid & 70g/L s/L ratio



# Ongoing & Future Activities

- Formation mechanisms of particles
- Functionalization for nanomedicine
- Omnivore closed-loop processes for recovering values
- Advanced characterization processes

Thank You!



Funded by  
the European Union

