

Batterifondsprogrammet

Co Cobalt 58.933

A

Aluminun

26.98



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#### **Recycling of discarded Li-Ion batteries (LIBs)**



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## Introduction

- Increasing political and consumer focus on climate change
  - Increase electric vehicle (EV) production
    - Increased lithium-ion battery (LIB) production





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Source: © OECD/IEA 2016, *Global EV Outlook 2016*, IEA Publishing

Photo:



## Introduction

- LIB is an important technology for electric vehicle (EV) high specific power, energy density and lifetime
- Ongoing development of battery composition



Publishing

## LIB material composition

#### • Cathode

- Lithium metal oxide, LiMeO<sub>2</sub>, graphite and PVDF binder on aluminum foil
- Metals used: i.e. Co, Ni, Mn, Al, Fe
- Anode
  - Carbon and PVDF binder on copper foil
- Electrolyte
  - Li salts and organic solvents (flammable).
- Plastic casing and electrical contacts and circuit
  - Plastics and electronics
- Electronic circuit
  - Serve as a guard
- Steel or aluminium casing
  - Steel (Fe, Cr, Ni), Al



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## Why is LIB recycling problematic?

#### • Economically viable?

- Earlier: Cobalt recovery
- Nowaday: ? Lower cobalt content

#### • Different battery chemistries

- All contain Li in cathode
- Electrolyte contain Li salts in solution

### Short circuiting / thermal runaway

System Electrodes	NCA Graphite	LFP(phosphate) Graphite	MS (spinel) Graphite	
Positive (Cathode)	$LiNi_{0.8}Co_{0.15}AI_{0.05}O_{2}$	LiFePO <sub>4</sub>	LiMn <sub>2</sub> O <sub>4</sub>	LULEÅ VERSITY F TECHNOLOGY
Negative (anode)	Graphite	Graphite	Graphite	

# Lithium ion batteries recycling processing routes

- Pre-treatments
  - Prevent short-circuits/ thermal runaways
  - Remove volatiles
- Mechanical processing
  - Crushing and sieving
- Pyrometallurgical processing
  - Pre-heating and smelting
- Hydrometallurgical processing
  - Separation of metals
  - Leaching
- Existing recycling routes
  - Combination of processes
  - Umicore
    - Heating/smelting process follow by leaching – recovering Co, Ni, Cu and Fe
  - Toxco process
    - Cooled in Nitrogen, mechanical shredding and hydrometallurgical process – recover LiOH<sub>2</sub> and metals
  - Sony-Sumitomo process
    - Incineration recovering Co from metallic residue





## LIB recycling processing routes

• Umicore process:



## LIB recycling processing routes

• Process for Co and metal recovery:



## LIB recycling processing routes

- Process for Li recovery
  - Designed for all types of Li containing waste



THE NORTHERNMOST UNIVERSITY of Technology in Scandinavia

## Wise Process Routes Battery recycling

By-products

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- Combination of mineral processing, hydro- and pyrometallurgy
- Beneficiation to enriched material streams
- Raw material streams to existing processes-flexibility
- Design for recycling