SUSTAINABLE ALKALI METAL CHEMISTRY: FROM SMALL MOLECULES TO MATERIAL SYNTHESIS

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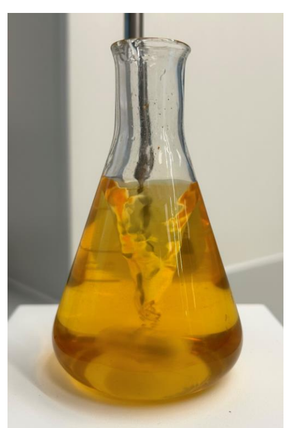
What is the Current Problem?

- The chemical industry is hugely important to the UK and is one of the largest industrial sectors, however, currently the chemical industry produces large amounts of waste and often energy intensive. Indeed, the chemical sector accounts for approximately 6% of global CO_2-equivalent emissions.
- Chemical reactions, such as the one pictured on the right, traditionally need to take place in solution-state which requires harmful/toxic solvents, often derived from crude oil, which leads to large amounts of waste.

How can we solve these problems with new chemistry?



Our Solution – Mechanochemistry

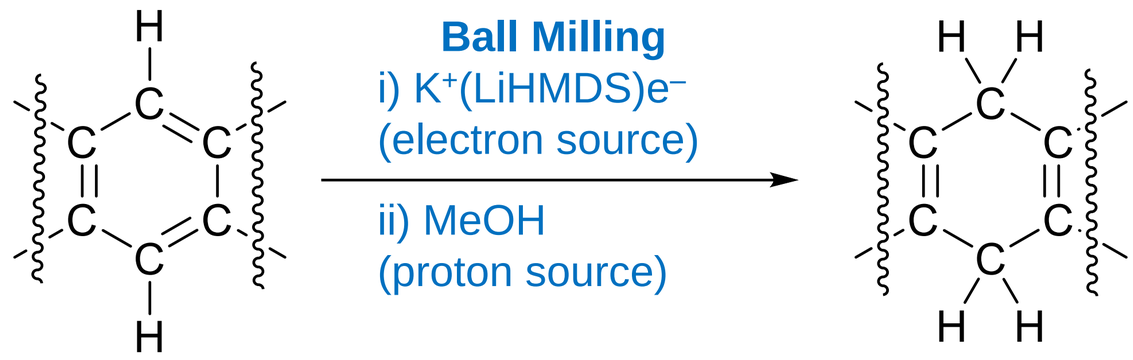
- Mechanochemistry (such as ball milling – pictured on the right) uses mechanochemical forces to directly promote chemical reactions in solid-state, with no solvent or external heating required, meaning faster, safer, cleaner manufacturing with less toxic waste.
- This research investigates the use of mechanochemistry in alkali metal chemistry. The alkali metals are some of the most abundant and low-cost metals of all the periodic table and play vital roles in chemical synthesis and everyday life from food to medicine to batteries.

Sustainable Organic Synthesis – Solvent-Free Birch Reductions

Current Liquid Ammonia-Based Synthesis

- The Birch reduction is a widely used de-aromatisation reaction, which involves dissolving alkali metals in liquid ammonia.
- However, liquid ammonia requires specialised equipment, is difficult to remove after a reaction and is dangerous to the environment, corrosive and toxic.
- Pfizer used the Birch reduction in the synthesis of an anti-Parkinson's drug candidate Sumanirole, which required the use of custom equipment and enough ammonia in the gas phase to fill 3 Boeing 747 planes.[1]

Mechanochemistry-Enabled Solvent-Free Birch Reductions

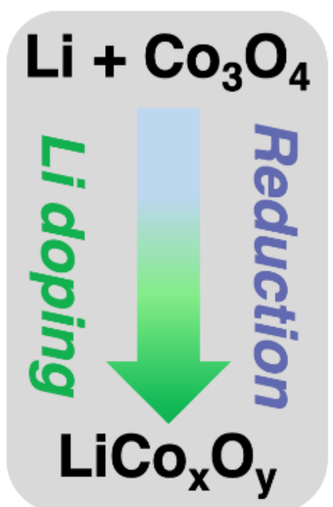


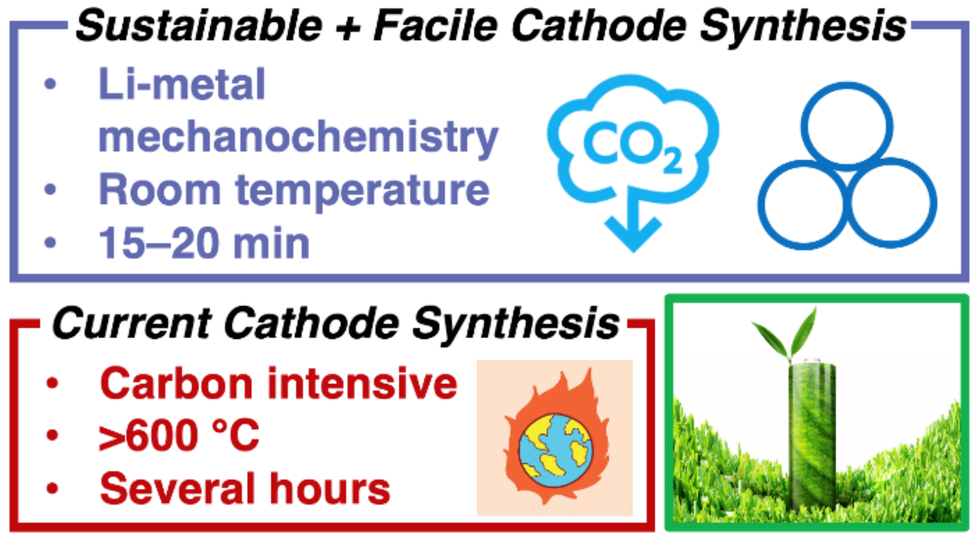
- No liquid ammonia
- Solvent-free
- Room temperature
- 20-25 minutes

- The new mechanochemistry protocol offers a fast and sustainable method of conducting the Birch reduction, removing not only the notorious liquid ammonia, but organic solvent altogether.[2]

Sustainable Battery Material Synthesis - Lithium Transition Metal Oxides

- The battery industry is fast expanding in the UK.
- Lithium transition metal oxides, such as lithium cobalt oxide (LiCoxOy), are essential materials in lithium-ion batteries. However, they are currently produced under energy- and carbon-intensive conditions, requiring high temperatures and long durations.
- Using mechanochemistry as new method of energy input, lithium cobalt oxide was synthesised in only 15-20 minutes at room temperature.[3]





References:
[1] *Org. Process Res. Dev.*, 2005, **9**, 997.
[2] *Chem,* 2023, **9**, 576.
[3] *Eur. J. Inorg. Chem.*, 2023, **26**, e202300344.