Using Magnetron Sputtering to Develop Heterogeneous Catalysts for Gas-Liquid Hydrogenation in Flow

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Gas-liquid hydrogenation reactions are key pharmaceutical transformations that benefit from transfer from batch to flow:

- Improved mixing and heat transfer
- Improved gas-liquid-solid contact
- Safer at elevated temperatures and pressures
- Higher throughput with a smaller equipment footprint

Hydrogenation reactions account for 10–20% of all reactions in the pharmaceutical industry[1]

Heterogeneous catalyst performance in flow is dependent on both the catalyst's chemical activity and mass transfer properties[2]

This interdependence is often overlooked in flow catalysis research

Catalyst performance:

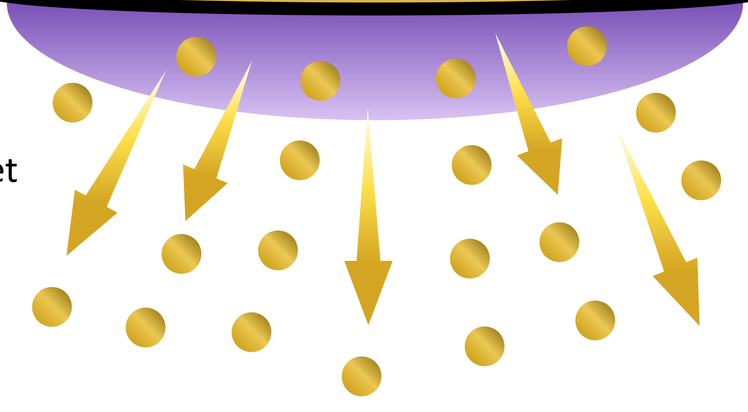

Powder


Pellet


Static mixer

	Powder	Pellet	Static mixer
Chemical activity	Good	Moderate	Poor
Mass transfer	Poor	Moderate	Good
Back pressure	Poor	Moderate	Good

Magnetron Sputtering

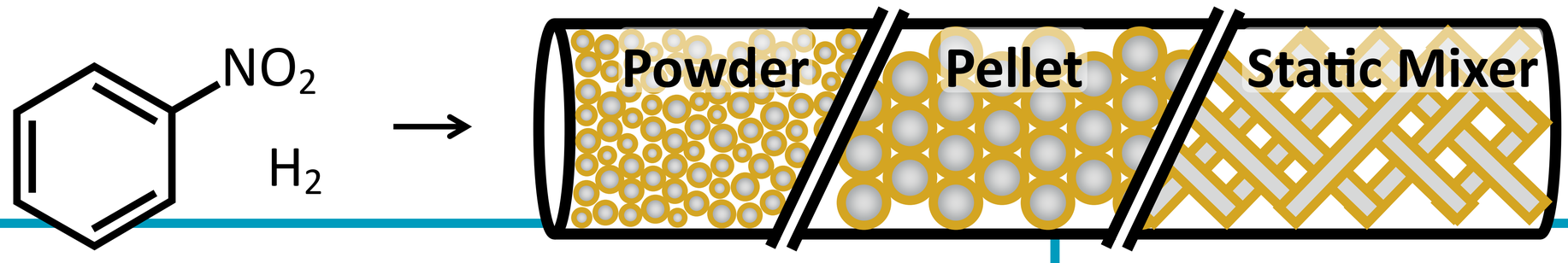


Catalyst synthesis

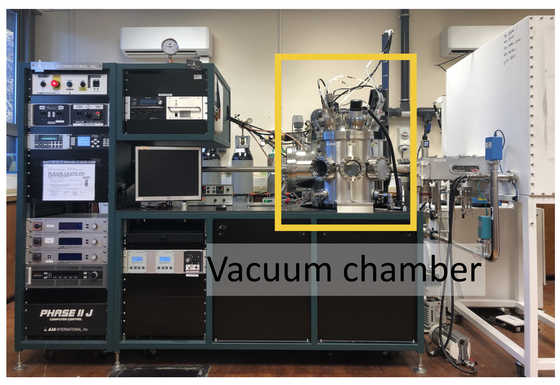
1. The process takes place inside a magnetron sputtering vacuum chamber
2. The catalyst support is placed below the metal target
3. Argon ions are fired at the metal target
4. Metal atoms are ejected from the target and deposited onto the support as nanoparticles[3]

Benefits compared to wet synthesis methods

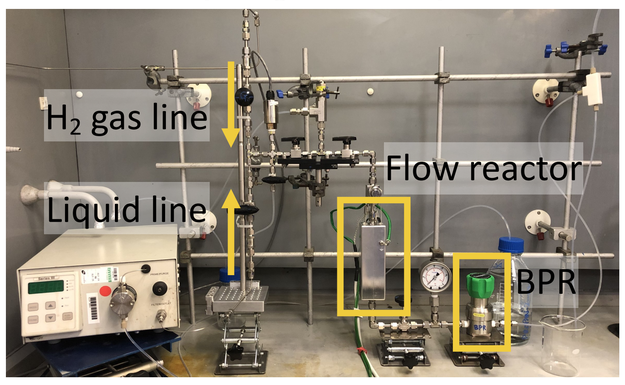
- ✓ Flexible support choice
- ✓ High control over metal nanoparticle loading
- ✓ Fast process (e.g., 1 g Pd/C pellets in 30 min)
- ✓ No solvents or chemicals required
- ✓ Reproducible and scalable

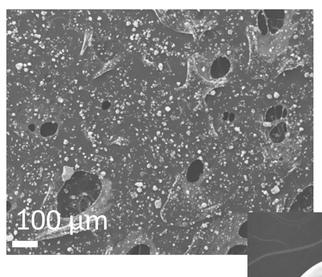


Magnetron sputtering equipment

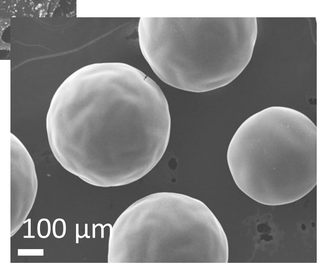


Flow hydrogenation system



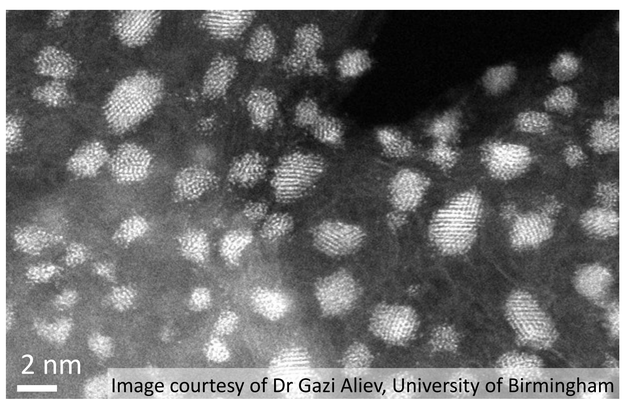


Carbon powder

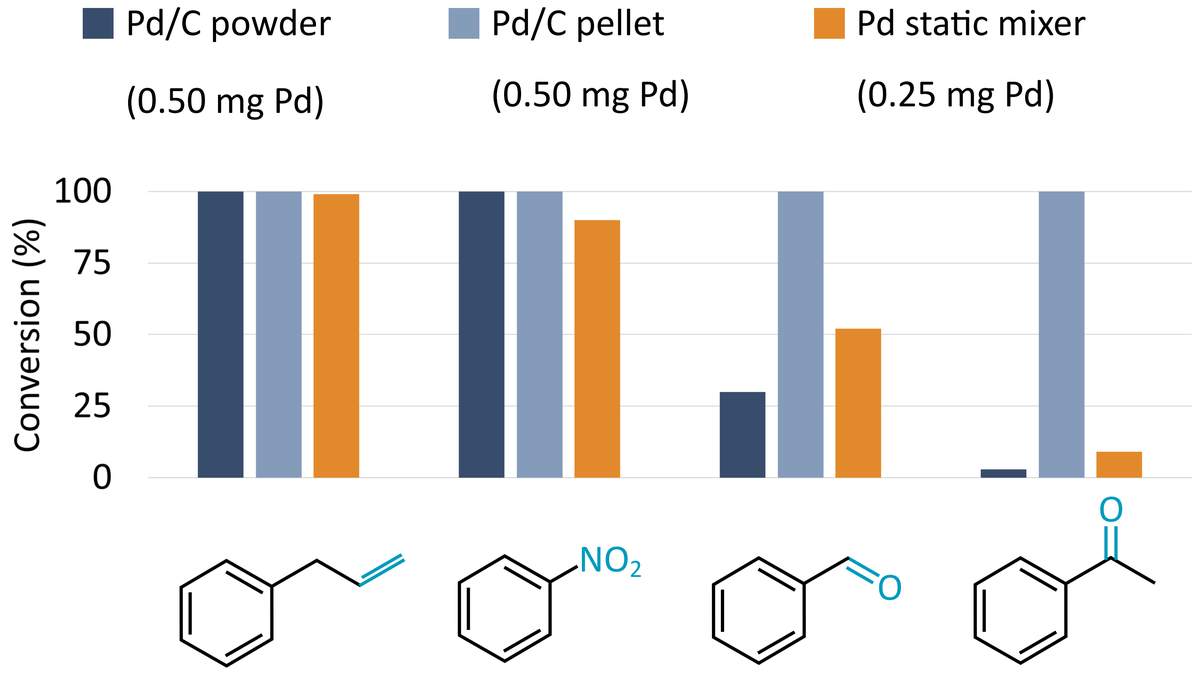


Carbon spherical pellets

Pd nanoparticles on carbon support



Reagent, 0.1 M EtOAc, 0.5 mL/min → Pd catalyst, H_2 at 2 mL/min, 120 °C, 20 bar, 90 s residence time → Product



Conclusion

- Powder, pellet, and static mixer catalysts were developed using magnetron sputtering and tested for the hydrogenation of small organic molecules
- Pellets gave the best overall performance due to their balance between chemical activity and mass transfer properties

1. L.J. Edwards, *et al.*, *OPR&D*, 2022, 26 (8), 2190–2223

2. V. Sans, *et al.*, *Nat. Commun.*, 2025, 16, 9062

3. I. Popov, *et al.*, *Nano Lett.*, 2023, 23 (17), 8006–8012

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