Exploring New Cathode Materials to Enable High Energy Magnesium Batteries

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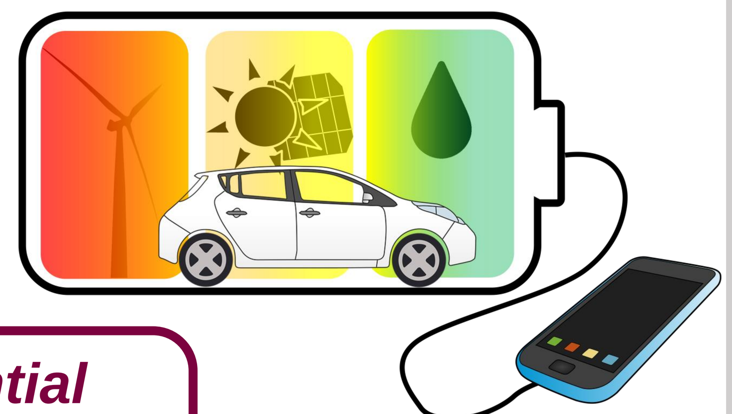
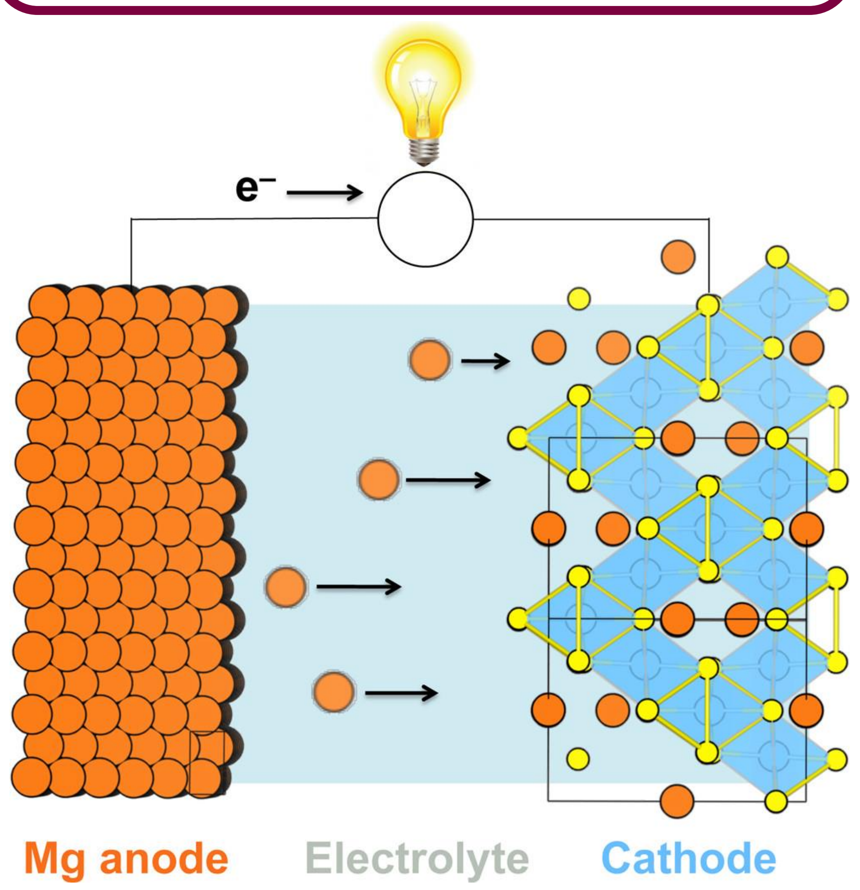
Motivation

Why Magnesium (Mg) Batteries?

- Novel technologies demand, **more powerful, lighter,** and **affordable,** energy storage devices **[2]**



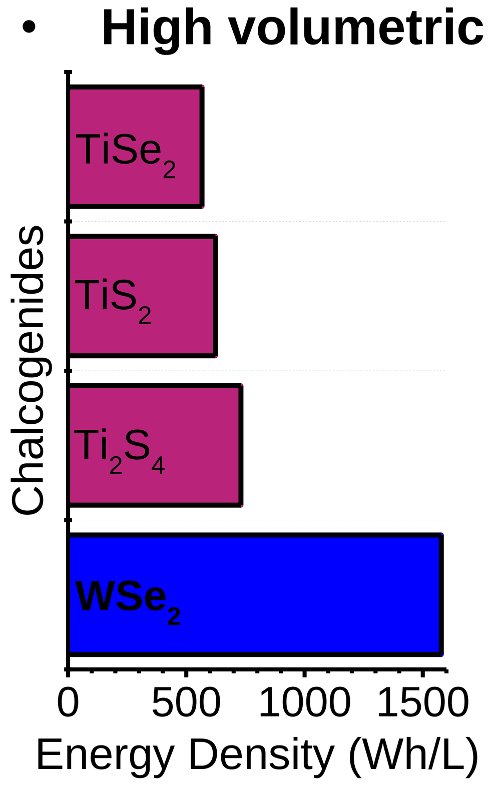
Magnesium: A Potential Alternative to the Lithium-ion Battery



- Mg has **~2x theoretical volumetric energy density** of lithium (Li) **[1]**
- Mg is **~1100x more abundant** than Li in the earth's crust **[4]**
- **We must discover more high capacity, high voltage cathodes for Mg batteries**

Why Investigate the Cathode Material, Tungsten Diselenide (WSe_2)?

- Quantity of stored ions defines **battery's capacity**
- **High volumetric energy density** of 1578 Wh/L **[1]**



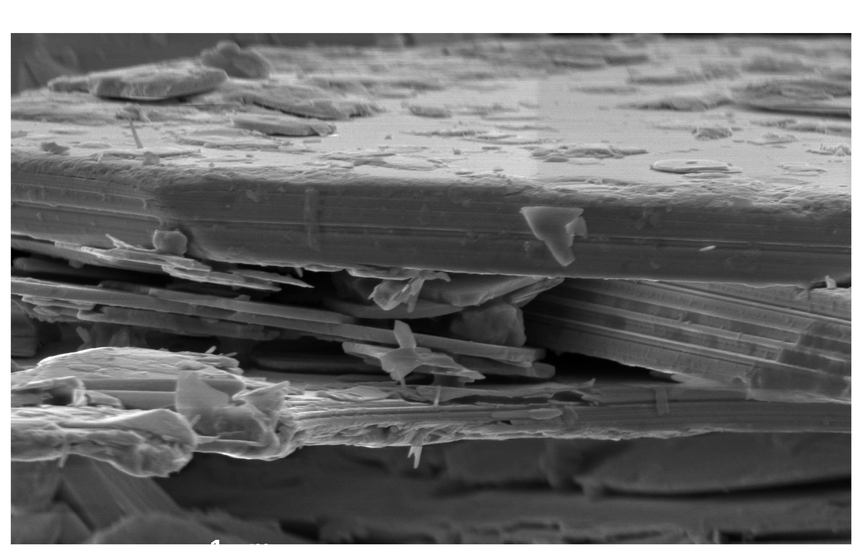


Figure 1: SEM image of WSe_2 layers

Objective: How does WSe_2's layered structure react when Mg ions are intercalated?

Reaching Reversible Reactions

Using a **three-electrode set up, reversible reactions** are achieved
WSe_2 gravimetric capacity, **~ 120 mAh g^{-1}**

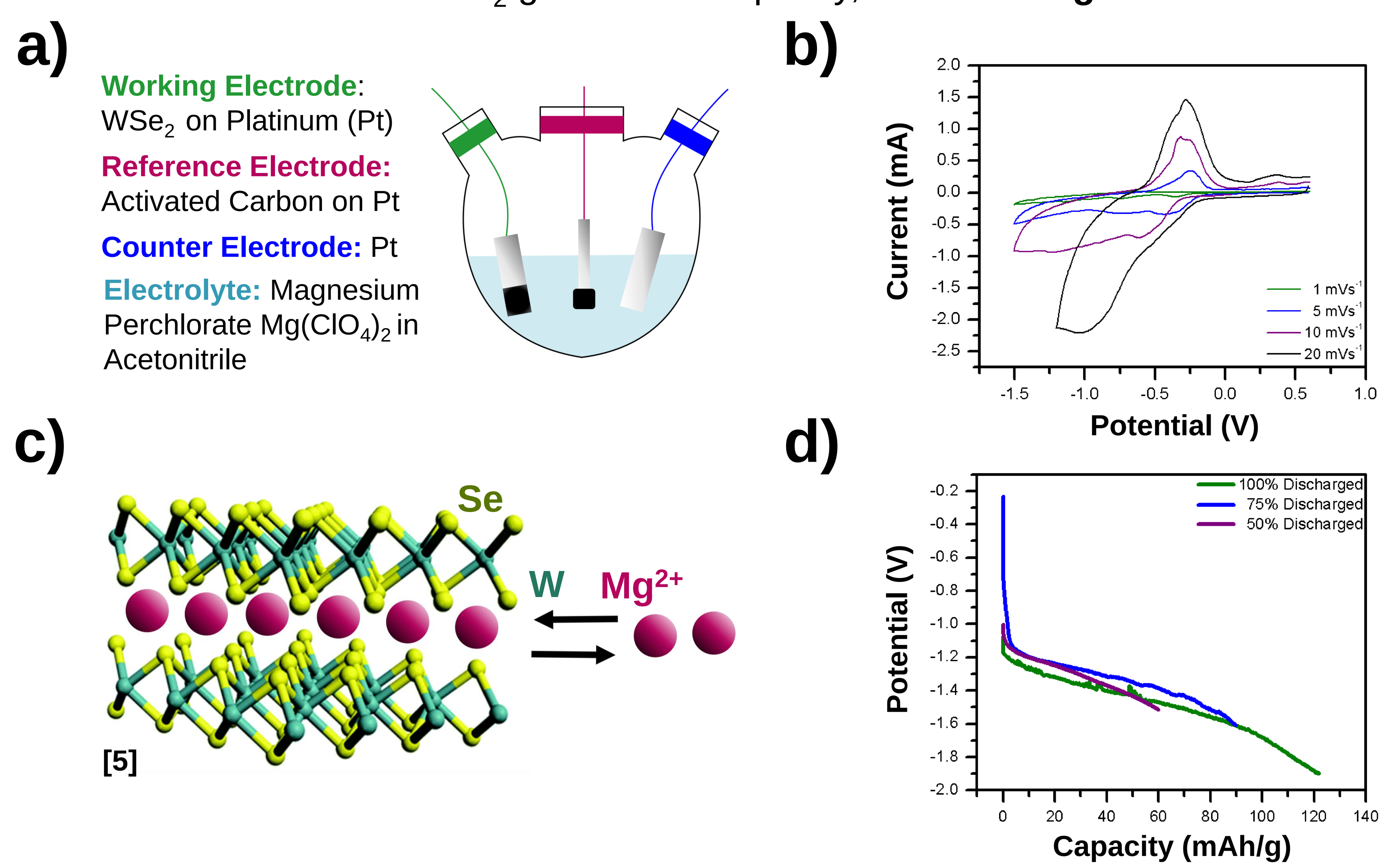


Figure 2: (a) Three-electrode cell experimental setup **(b)** Voltammograms at 1, 5, 10, and 20 mVs^{-1} scan rates **(c)** Proposed mechanism for Mg^{2+} storage **(d)** Curves at 100%, 75%, and 50% discharge states

WSe_2 Lattice Expansion

Using **X-ray Diffraction (XRD)** and **Raman spectroscopy** to **evaluate proposed reaction mechanism,** we prove that the **lattice expands** to accommodate Mg ions

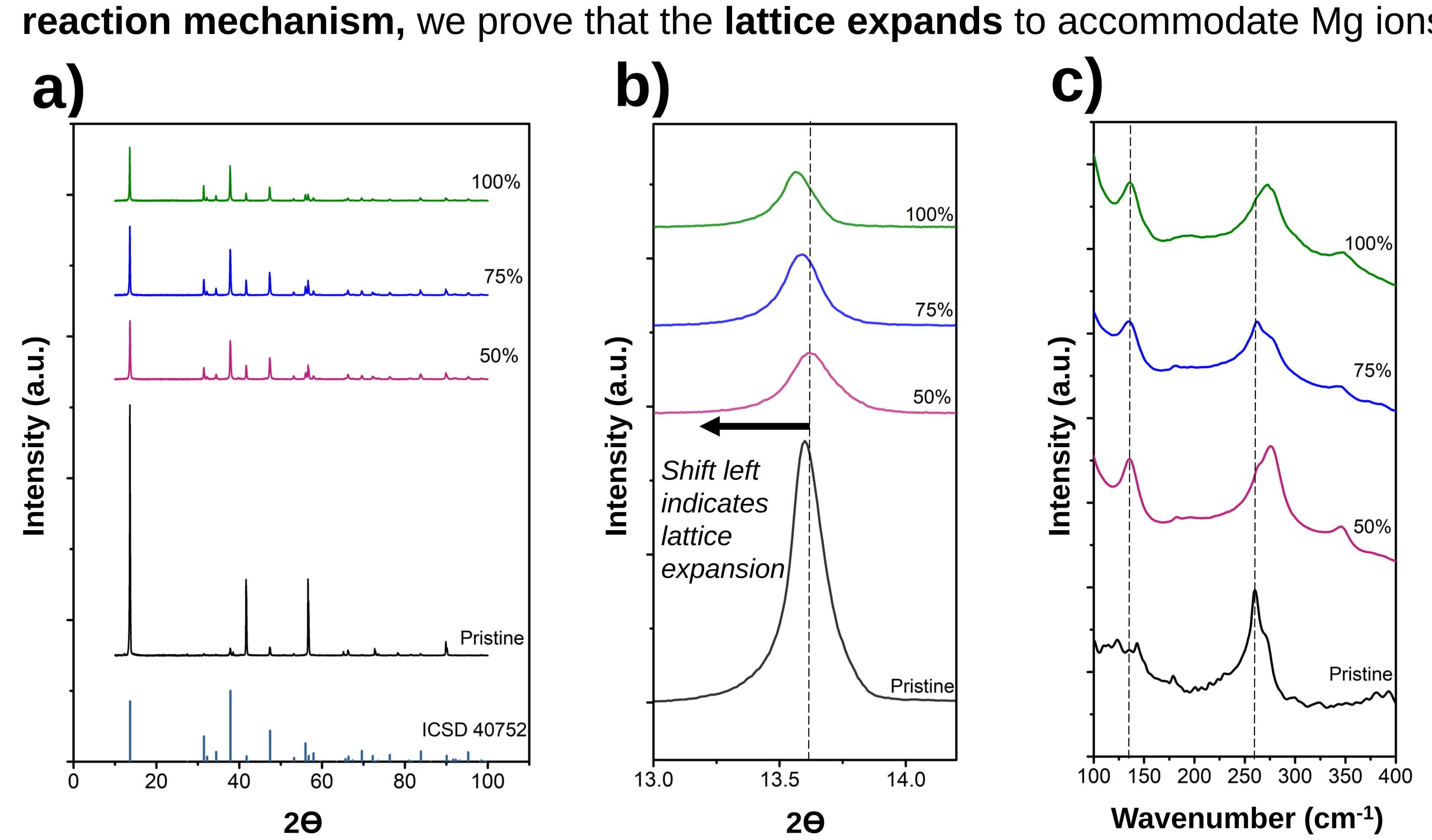
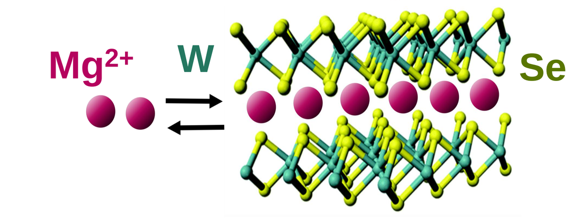


Figure 3: (a, b) XRD patterns **(c)** Raman spectra of WSe_2 discharging for 5, 7.5, and 10 hours

Conclusion

Our findings indicate a mechanism of reversible intercalation of Mg^{2+} into WSe_2



Why Is This Important?

- **In Li^+ and Na^+ batteries, WSe_2 is known to initiate chemical conversion reactions, instead of intercalation reactions, that are poorly reversible and inefficient.**
- **Measured performance of WSe_2 for Mg^{2+} batteries opens a pathway toward energy dense multivalent ion batteries that surpass current Li-ion technologies.**

Future Work

- **Determine battery longevity** from cycle life data of WSe_2
- **Improve kinetics and storage capacity** with exfoliated bulk WSe_2

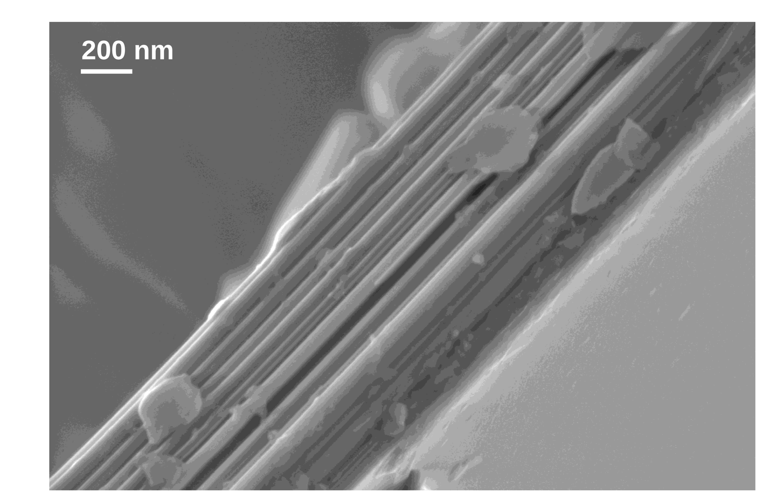
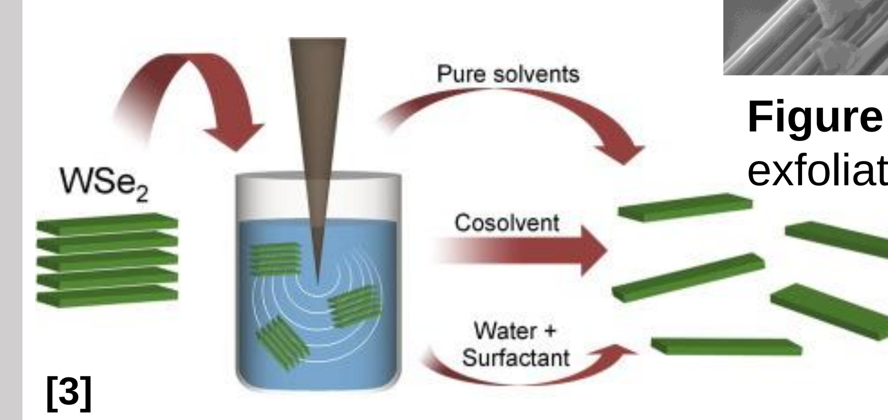


Figure 4: SEM image of pre-exfoliated WSe_2



[3] *Exfoliation of bulk WSe_2 into monolayers*

References

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