**Technical Report: Scale-Up Scenario for 1 Tonne Ti₃C₂ MXene Production**

**1. Reactor Capacity Assessment**

Two 20 m³ reactors operating at 85% working volume each provide **17,000 L** of liquid capacity per reactor.  
Given the scaled recipe (**30 mL liquid per 1 g Ti₃AlC₂**), this corresponds to approximately **33.3 g MAX per liter**.

* MAX per reactor ≈ **566.7 kg**
* Total for two reactors ≈ **1,133.3 kg**

The required MAX for 1 tonne of Ti₃C₂ is **1,160.97 kg**, leaving a **shortfall of ~27.6 kg (2.4%)**.

**Options to compensate:**

* Increase working fill to ~87.8% (instead of 85%).
* Use slightly larger tanks (e.g., 2 × 21 m³).
* Add a small auxiliary feed vessel for the excess material.

**2. Production Time Feasibility**

While the reactors can nearly accommodate the full feed, completing the process within a single day is unlikely.

**Key bottlenecks include:**

* **Etching:** Typically requires ~24 h under HF/HCl conditions.
* **Washing/neutralization:** Multiple centrifugation and wash cycles may require **1–3 days** at scale.
* **Delamination:** Often overnight or several hours.
* **Drying:** May require **1–2 days** depending on dryer throughput.
* **Handling & safety:** Adds further time delays.

**Conclusion:** Etching can be completed in one day, but washing, delamination, and drying extend the campaign to **3–6 days** depending on downstream equipment availability.

**3. Scheduling Options**

* **Option A – Standard Throughput:** One-day etch, with washing, delamination, and drying over 2–4 additional days.  
  → Total = **3–6 days** per campaign.
* **Option B – High Throughput:** Parallel downstream centrifuges and dryers could compress finishing steps to **1–2 days**.  
  → Requires significant extra infrastructure.
* **Option C – Smaller Batches:** Running smaller but faster-turnaround batches can improve operational safety and flexibility,  
  but increases overall campaign duration.

**4. Summary of Key Findings**

| **Parameter** | **Value** |
| --- | --- |
| Reactor Size | 2 × 20 m³ (85% fill = 17,000 L each) |
| MAX per reactor | ~566.7 kg |
| Total MAX capacity | ~1,133.3 kg |
| Required MAX | 1,160.97 kg |
| Shortfall | 27.6 kg (~2.4%) |
| Etch duration | ~24 h |
| **Etching Reactor Power Requirement** | ≈ 240–300 kW installed load, ≈ 60,000–80,000 kWh per campaign |
| Washing | 1–3 days |
| Delamination | Several hours – overnight |
| Drying | 1–2 days |
| **Total campaign** | 3–6 days realistic |

**5. Conclusion**

This analysis demonstrates that **two 20 m³ reactors are nearly sufficient** for the 1-tonne MXene campaign, but production times realistically extend beyond one day due to downstream operations.

The **etching reactors alone require 240–300 kW installed power**, consuming ~60–80 MWh per 1-tonne campaign.  
Process scheduling and downstream equipment scaling are critical factors for industrial feasibility.