SELF-PROPAGATING HIGH-TEMPERATURE SYNTHESIS OF SILICON USING PLANT-BASED SILICA

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INTRODUCTION

- Porous silicon has wide-ranging applications in biomedicine, electronics, and energy storage, yet traditional synthesis methods remain costly and difficult to scale. This research explored a greener alternative using plant-based silica (tabasheer) and a 9V electric current to drive a magnesiothermic reduction reaction, in which silica acts as the oxidant and magnesium acts as the reductant.
- To keep the process affordable and eco-friendly, a wooden block served as the reaction chamber and tungsten wire was selected for its durability at high temperatures, with NaCl added as a thermal stabilizer throughout the reaction.
- XRD, SEM, and EDX analyses revealed crystalline silica as the major product rather than elemental silicon, with only an indistinguishable amount of silicon detected, suggesting incomplete reduction and identifying reaction time and voltage as key variables that require further optimization.
- While not the intended outcome, crystalline silica has well-established practical uses, and these results provide a clearer direction for refining the reaction conditions in future experiments.

PROCEDURE

Magnesiothermic Reduction Reaction

$$SiO_{2(s)} + 2Mg_{(s)} \xrightarrow[600^{\circ}C \text{ or } 9V]{NaCl} 2MgO_{(s)} + Si_{(s)}$$

1. **Preparation**: Grind SiO_2 (tabasheer), Mg, and NaCl together. Pack into closed reaction chamber.
2. **Ignition**: Apply 9V electric current for ~15 min in a fume hood. SiO_2 is an oxidant, and Mg is a reductant.
3. **Collection**: Cool the chamber to ambient temparature before opening. Separate the product on from the unreacted residue.
4. **Acid wash**: Dissolve in hot conc. HCl (~70°C) for 2 hours. Vacuum filter and wash to remove byproducts.
5. **Characterization**: Analyze the purified product using XRD for structure, SEM morphology, and EDX elemental composition

RESULTS

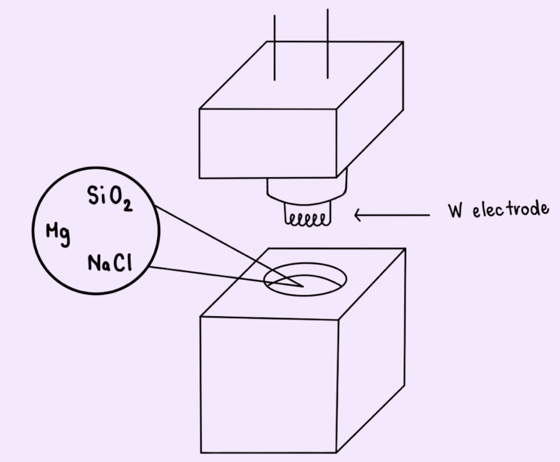

Figure 1. Wooden Reactor

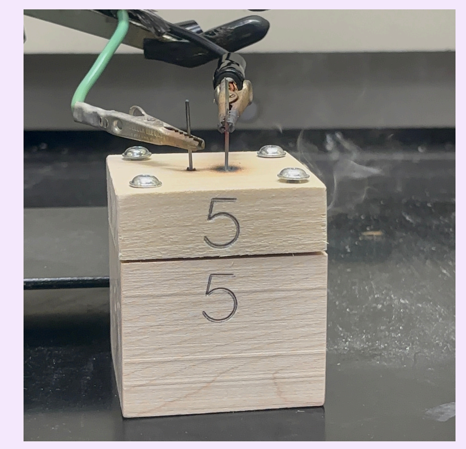

Figure 2. Experimental Wooden Reactor

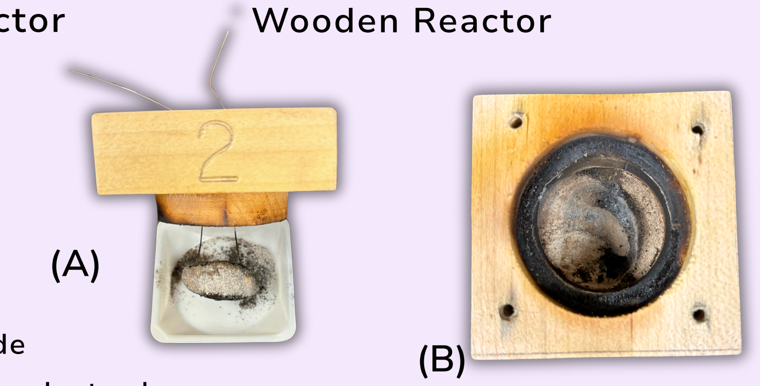

Figure 3.
Reacted collected products
(A) Product near the electrode
(B) Product far away from the electrode

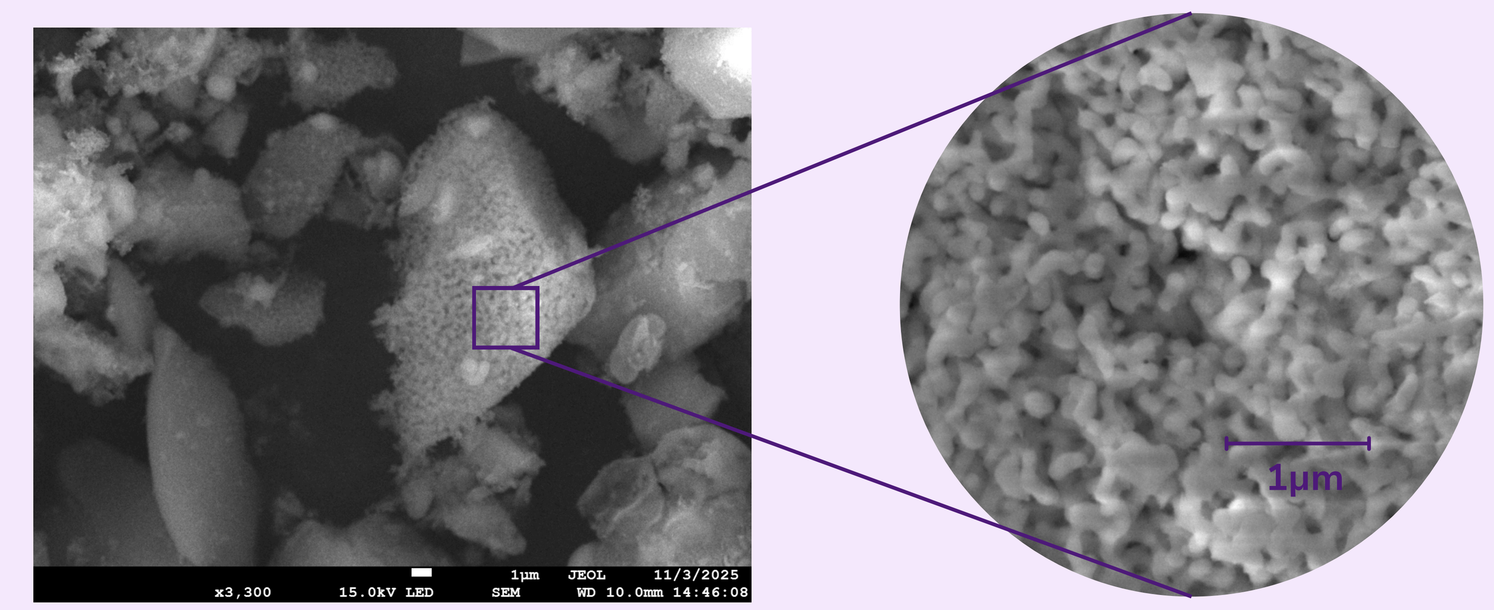

Figure 5. Field Emission Scanning Electron Microscope for the reacted sample at 9V for 15 minutes at 1µm scale bar.

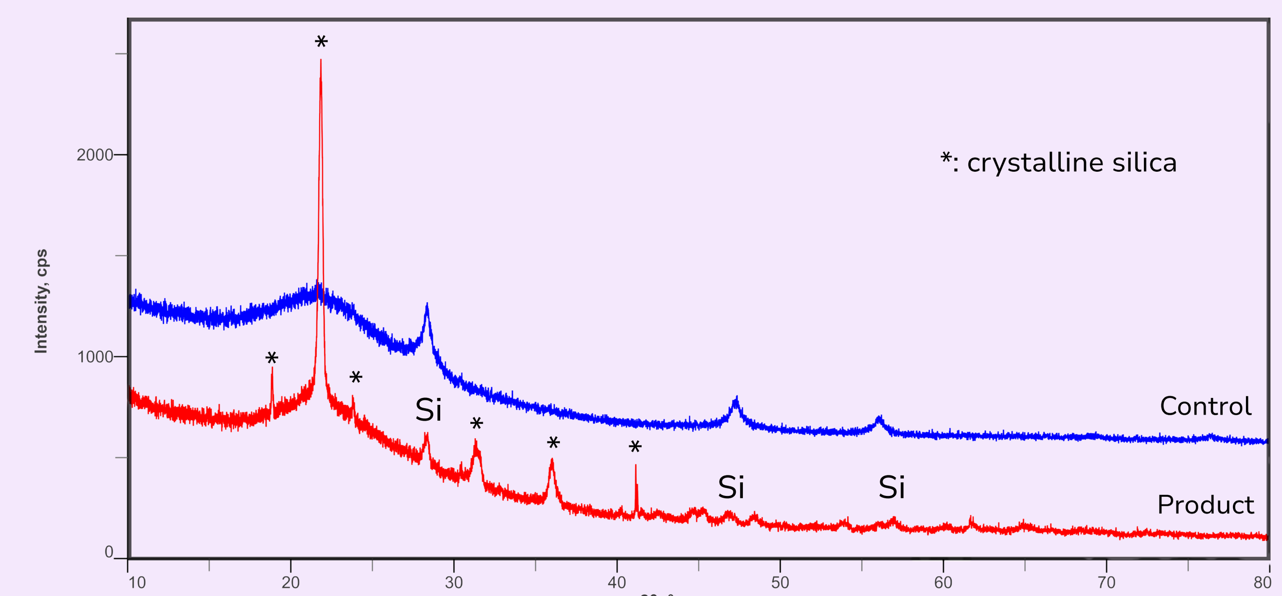

Figure 4. Rigaku Powder X-ray Diffraction (XRD) pattern of reacted sample at 9V for 15 minutes

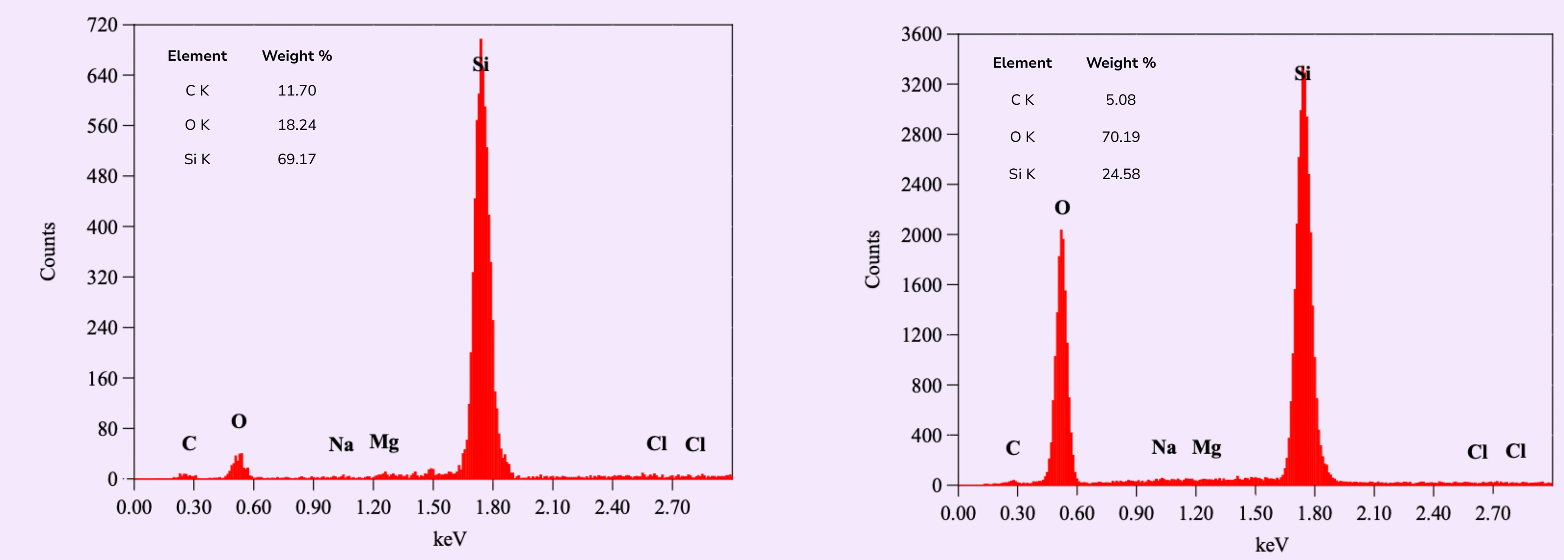

Figure 6. Energy Disperive X-ray (EDX) Spectra of the products after acid treatment at 9V for 15 minutes (the square area in the Figure 5)

CONCLUSIONS AND FUTURE WORK

- The formation of porous silicon and crystalline silica appears to be competitive, consistent with Le Chatelier's Principle, where preferential crystalline silica formation decreases the yield of the desired porous silicon product.
- Lower voltage provided greater control over reaction conditions, but the amount of porous silicon produced remained too small to be clearly distinguished from crystalline silica.
- Further reducing the voltage to 3V still yielded crystalline silica as the dominant product, suggesting that particle size, reaction time, and precursor ratios may be more critical variables for future optimization.

REFERENCES

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