Photocatalytic Hydrogen production using recovered Silicon from end of life photovoltaic panels

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Introduction

- Increased solar photovoltaic panel deployment
- Large amounts of waste expected by 2030
- Sustainable management of PV waste
- Prevention of metals leaching to environment

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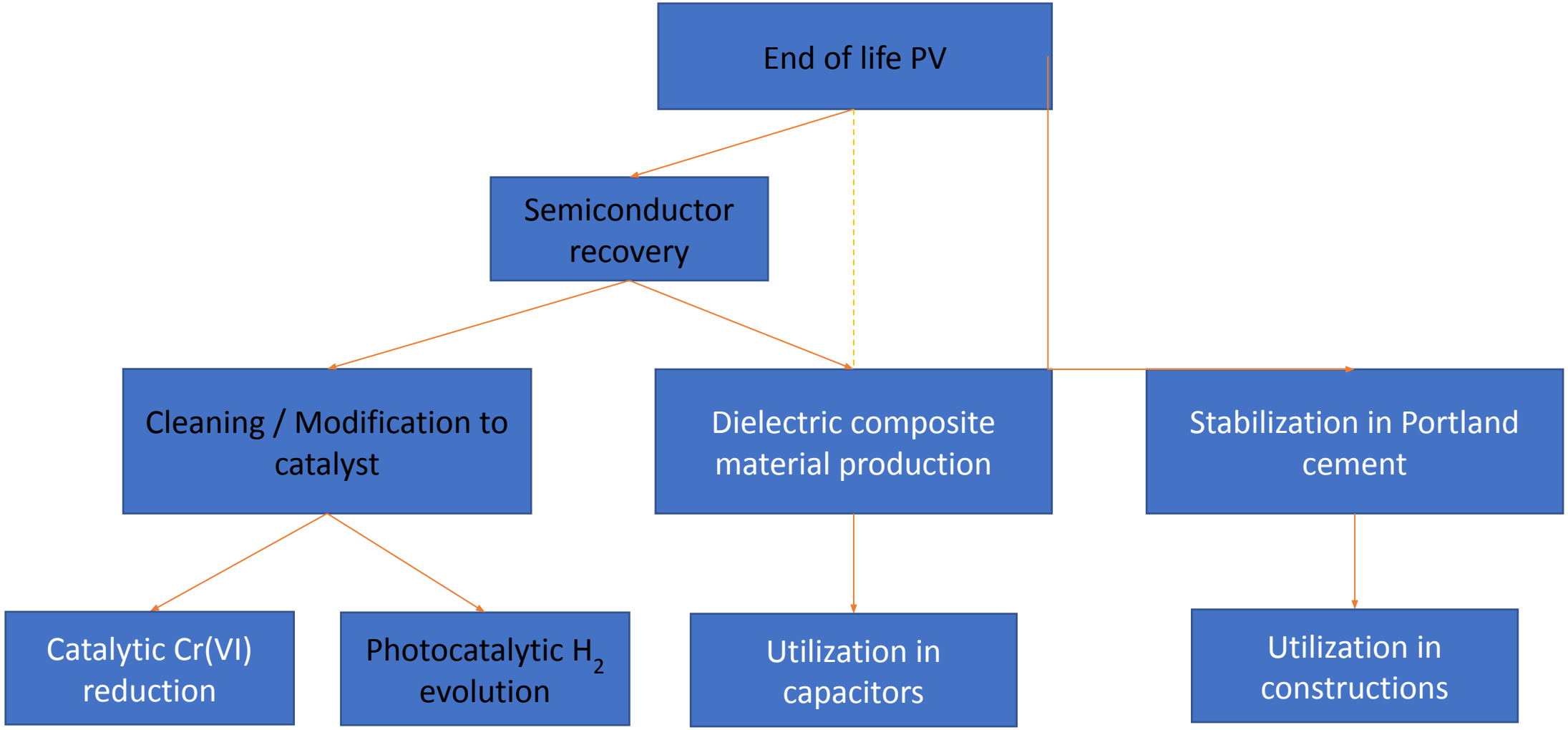

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Silicon cell recovery

Figure 1. Polycrystalline PVP

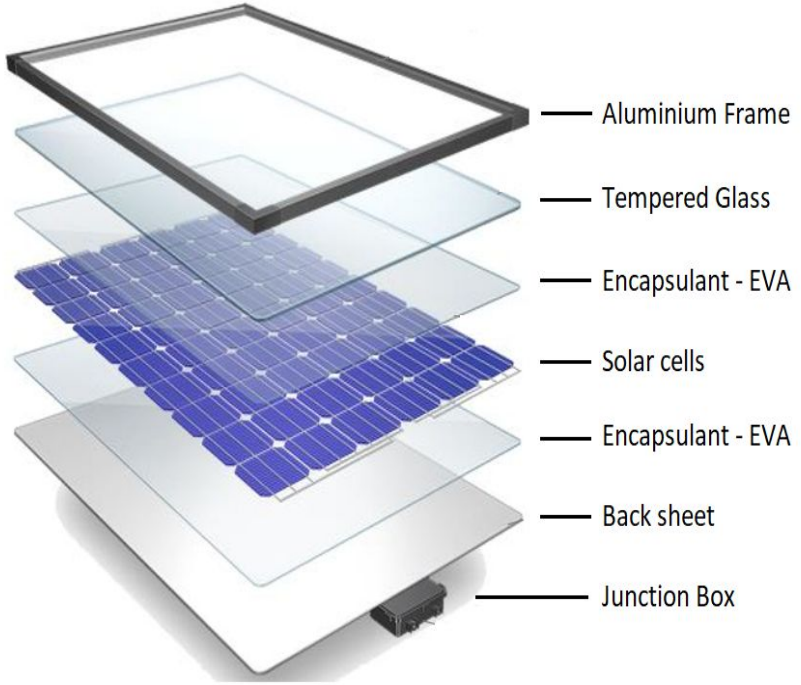

Figure 2. 1st generation PVP structure

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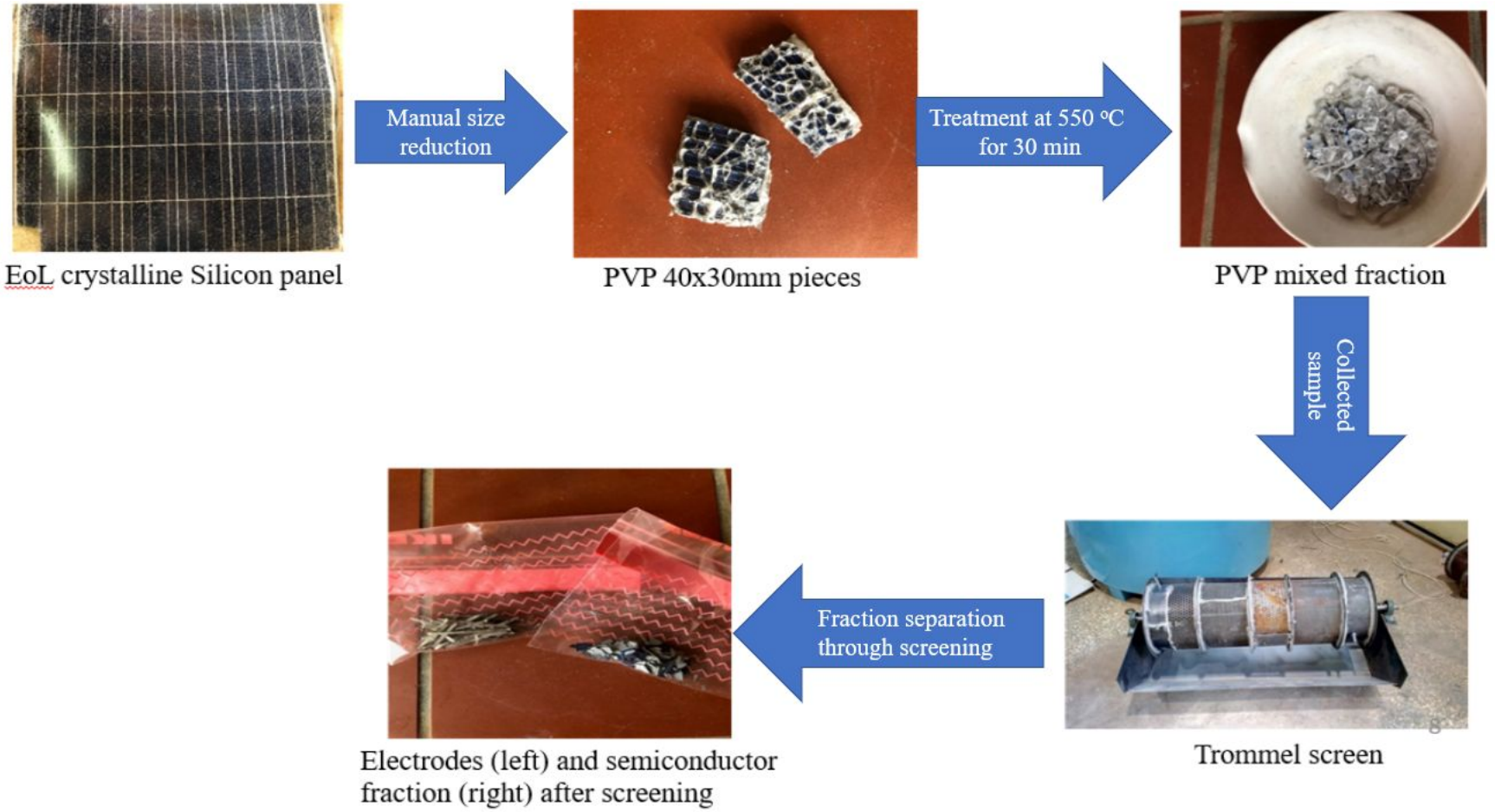

Figure 3. Silicon cell recovery process

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Silicon cell cleaning

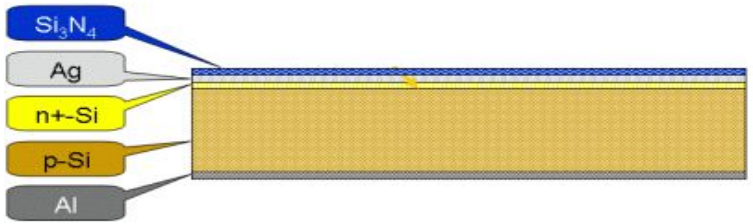
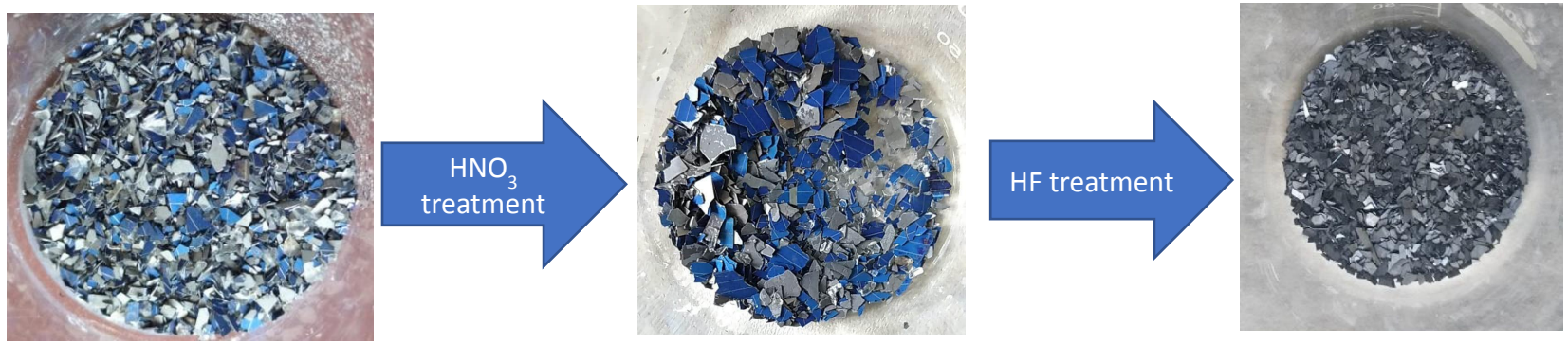


Figure 4. 1st generation solar cell structure



Metal Recovery → Si_3N_4 / Al Removal → ***Recovered Silicon***

Figure 5. Silicon cleaning process

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Recovered silicon modification

1 step Ag Assisted Chemical Etching

Chemical Etching
- 4.6 M HF / 0.035M $AgNO_3$ aquatic solution
- 30 min at 55°C

Residue removal
- Oxide removal with 10% w/v HF
- 1 min at room temperature

Cu doping
- 1.4M HF / 0.035M $CuSO_4 \cdot 5H_2O$ solution
- 2 min at room temperature

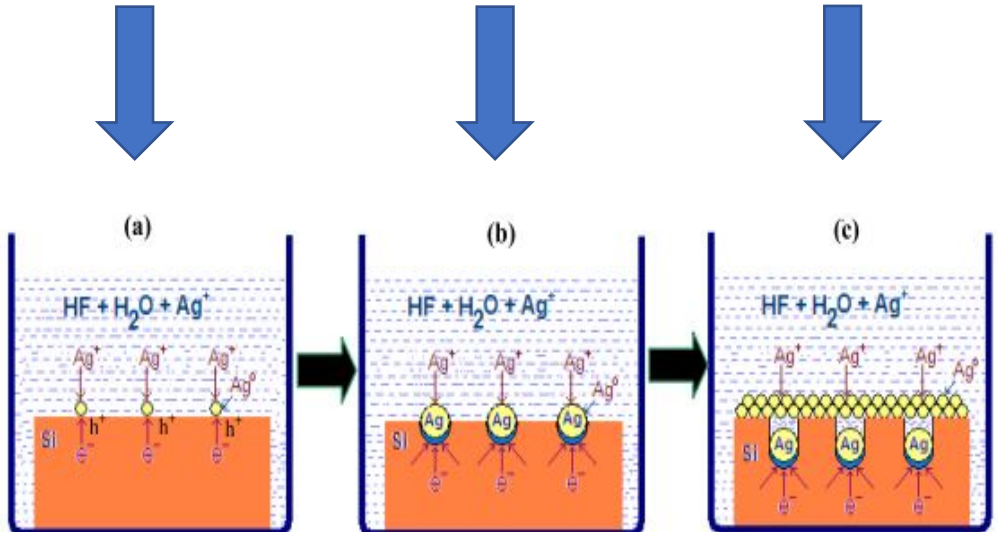

Figure 6. Single step Ag assisted chemical etching (Srivastava et al., 2014)

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Photocatalytic Experiments

Figure 7. Photoreactor set up by Peschl Ultraviolet GmbH, Mainz -Germany

- $V_{reactor}$: 600mL
- $V_{headspace}$: 275mL
- Radiation source: 150W Hg arc lamp

Conditions:

- Temperature: 55 °C
- Stirring: 600 RPM
- 1.3 g_{cat}/L catalyst powder (Si or TiO_2)
- Inert Ar atmosphere
- 3% v/v Methanol solution

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Results at basic pH

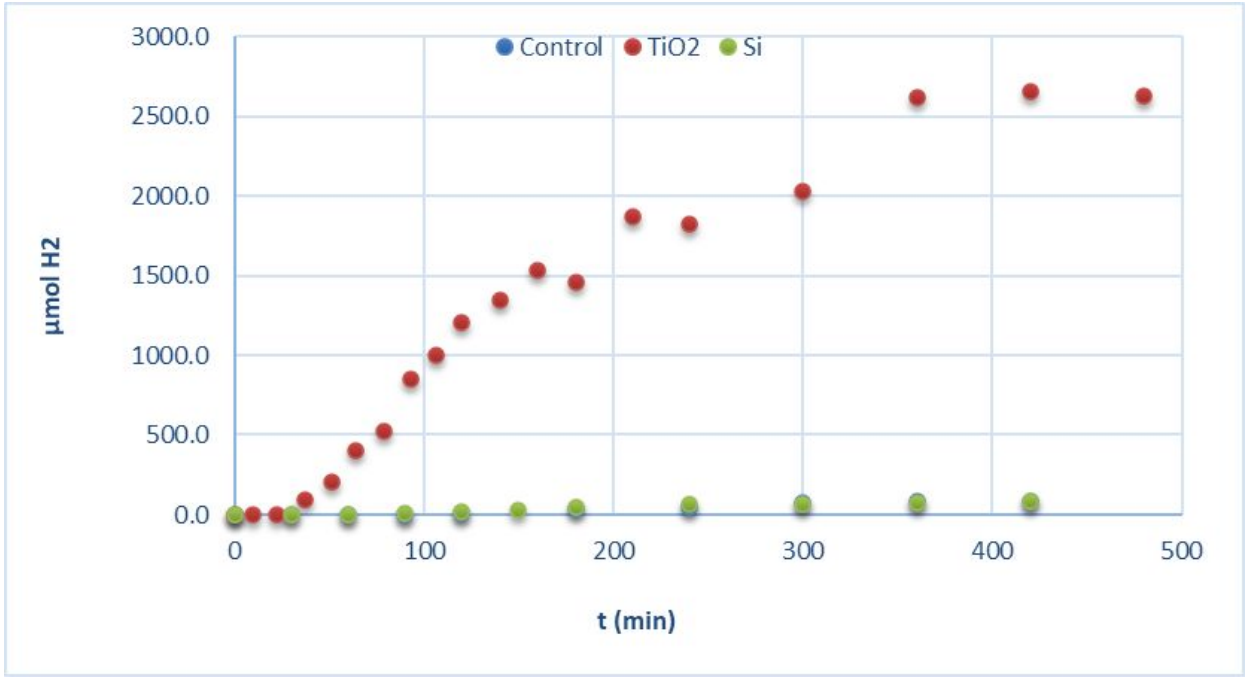

Figure 8. Photocatalytic H_2 production under UV irradiation in pH 10 with Si, TiO_2 photocatalysts and control experiment.

- Enhanced photocatalytic production using TiO_2, as expected.
- Recovered and modified silicon did not display photocatalytic activity.

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Results at neutral pH

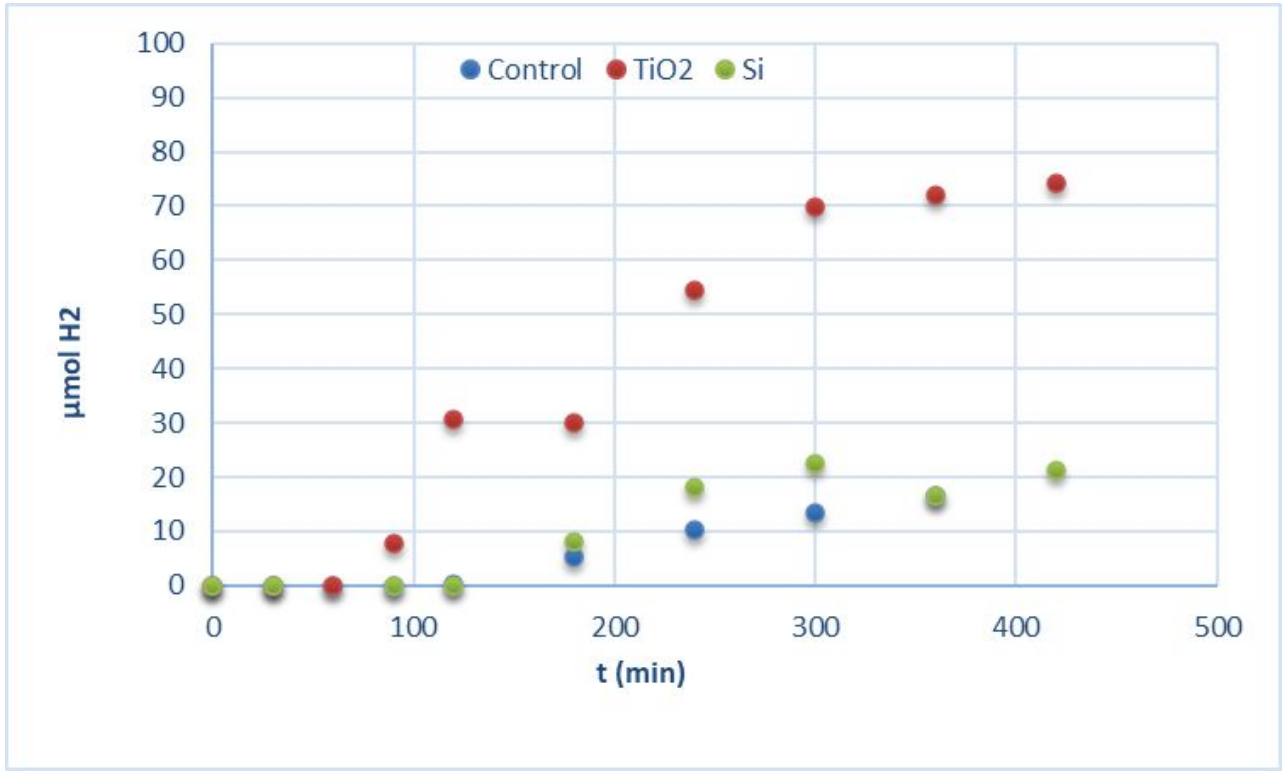

Figure 9. Photocatalytic H_2 production under UV irradiation in pH 7 with Si, TiO_2 photocatalysts and control experiment.

- Low production rates in all cases

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Results at acidic pH

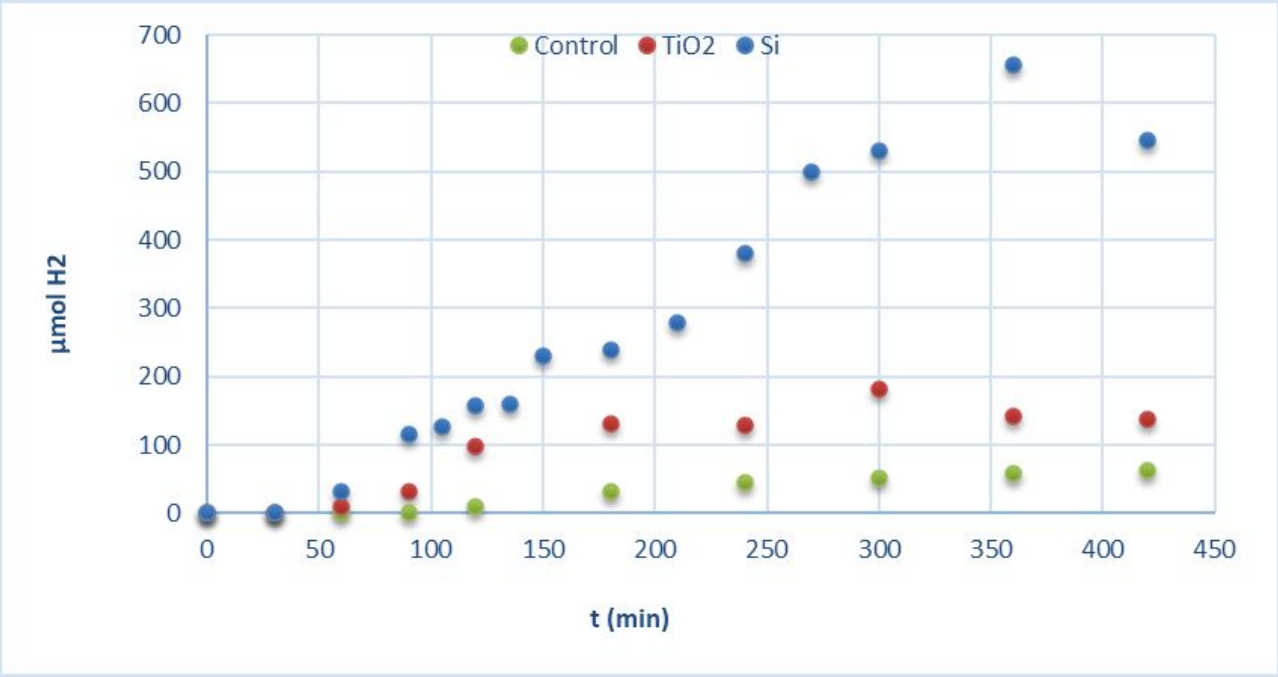

Figure 10. Photocatalytic H_2 production under UV irradiation in pH 3 with Si, TiO_2 photocatalysts and control experiment.

- Enhanced photocatalytic production using recovered and modified silicon.
- Improved evolution compared to control experiment and TiO_2 at these conditions.

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Experiments using stabilized Si catalyst

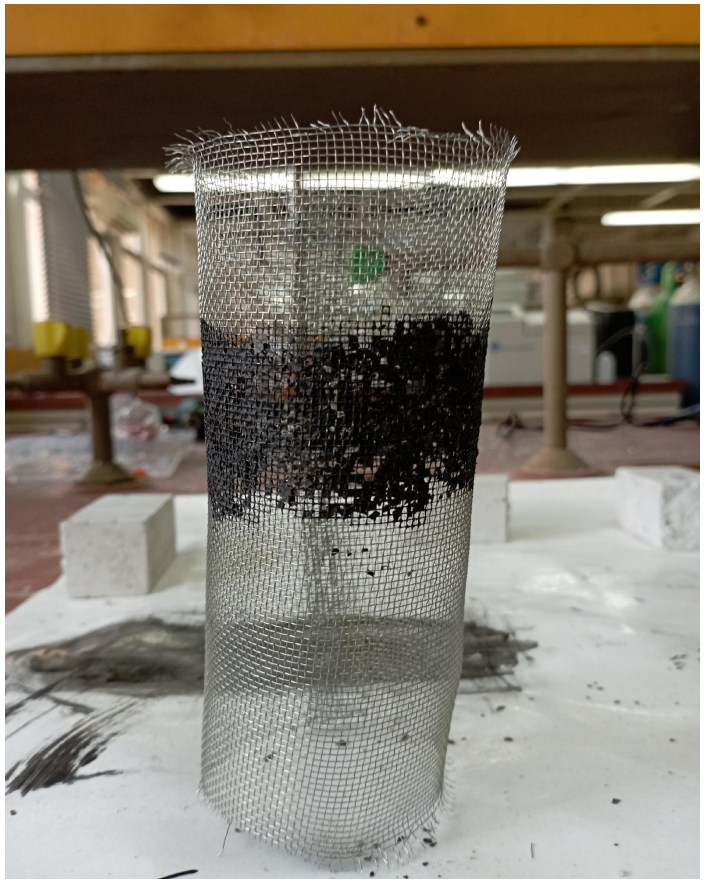

Figure 11. Si photocatalyst stabilized on stainless steel mesh using carbon paint.

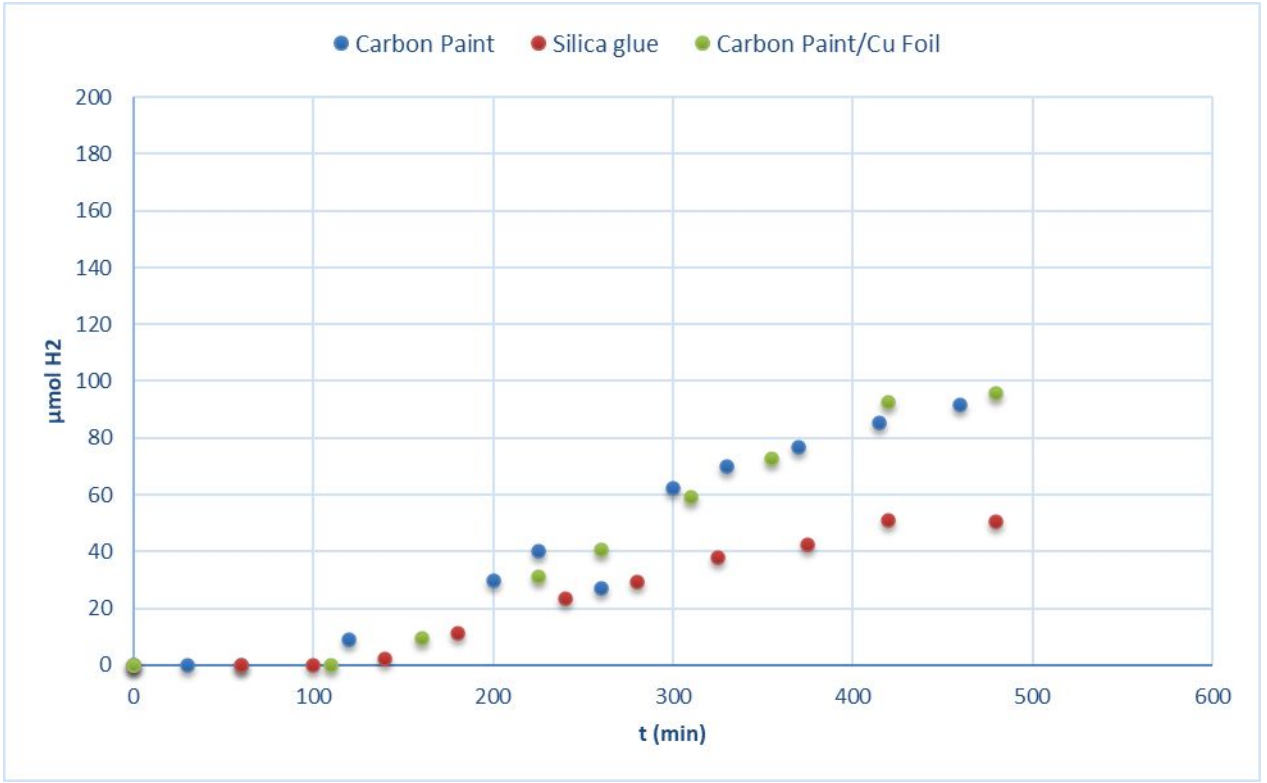

Figure 12. Photocatalytic H_2 production under UV irradiation, in pH 3, with stabilized Si photocatalyst using carbon paint, silica glue and carbon paint on Cu foil.

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Conclusions

- Silicon from 1st generation photovoltaic panels was successfully recovered and cleaned.
- After modification, recovered Si was able to provide significant hydrogen evolution under UV irradiation and acidic conditions.
- Si powder dispersed in the methanol solution displayed higher performance compared to Si stabilized on a stainless steel mesh.

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Work in progress

Goal

Achieve efficient photocatalytic water splitting using recovered Si under solar radiation.

Enhancement

I. High energy ball mill for additional size reduction

II. Pt particle decoration instead of Cu for increased photocatalytic performance.

Comparison with metallurgical grade Si to highlight the potential importance of recovering crystalline Si from end of life photovoltaic panels.

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Thank you for your attention!

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