Upcycling Waste Silk into Solar Energy Storage Silk via Wet Spinning

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Background

- China produces over 150K ton silk each year, and generates silk waste over 50k ton. It is an attractive upcycling way to convert the waste silk into functional filament via wet spinning.
- Solar energy is a sustainable energy source for personal warming textiles. Herein, we developed solar energy storage silks by incorporating long-lasting phosphorescent pigments inside, which absorb solar light in daytime and release light continuously over night.
- Near-infrared (NIR) radiation has widely been applied for phototherapy based on its beneficial thermal effect on human tissue. Thus persistent NIR-emitting fibers have also been fabricated by coating fluorescent Ag2S quantum dots (QDs) on the fiber surface. The core phosphor, serving as a solar energy reservoir and continuously emitting light to stimulate the surface coated Ag2S. Such fibers and textiles are especially helpful to the people living in desert areas, where the air temperature varies significantly at day and night.

Objective and Scope

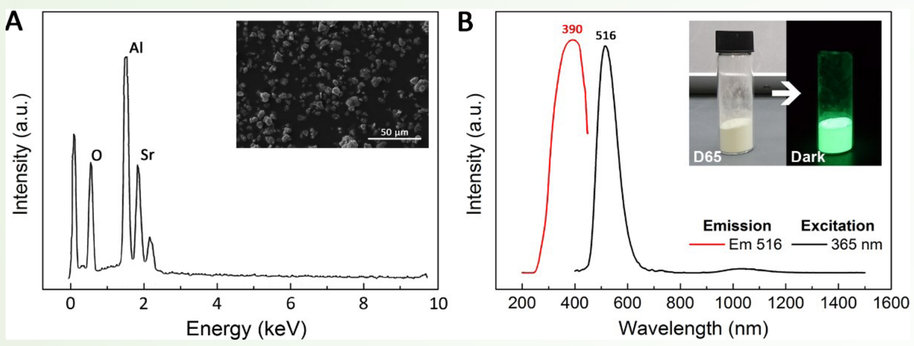
Objective: to explore the feasibility of upcycling silk waste into core-sheath silk with additional functions, particularly for solar energy storage.

Scope:

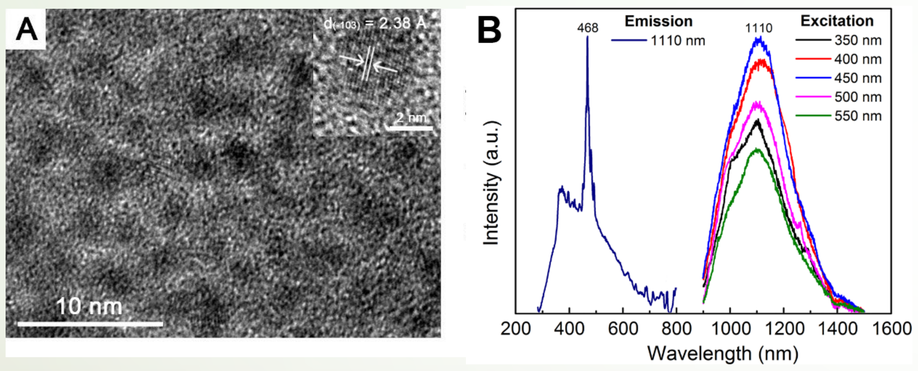
- **Core-sheath Silk spinning:** wet spinning equipment, fiber morphology
- **Solar Energy storage and release:** phosphorescence, wetting test

Phosphorescent Pigments & Quantum Dots

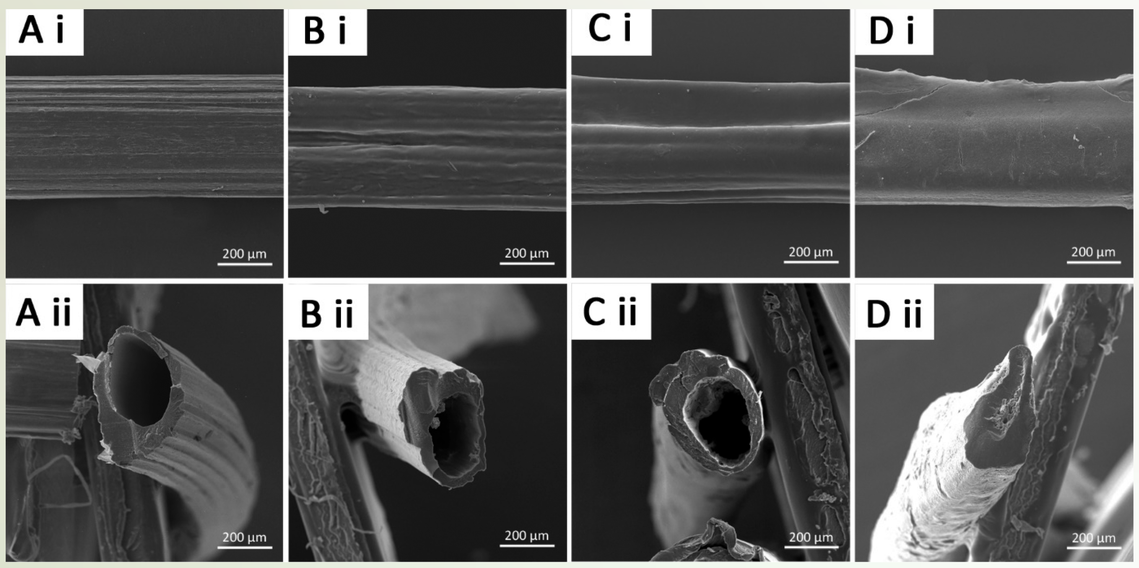
Phosphorescent pigments: the microparticles are excited around 390 nm, and emit green light around 516 nm.



Fluorescent quantum dots: the qauntum dots emit NIR at 900~1400 nm

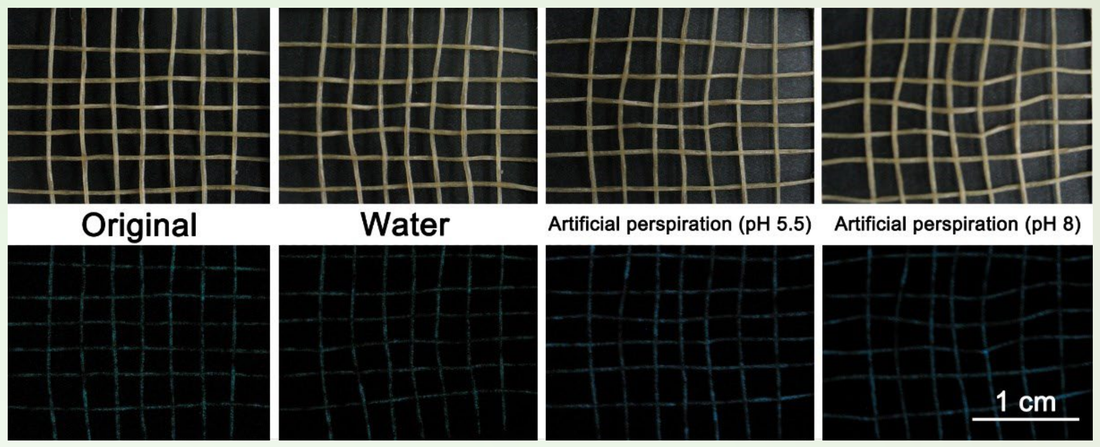


Wet Spinning of Core-sheath Fibers



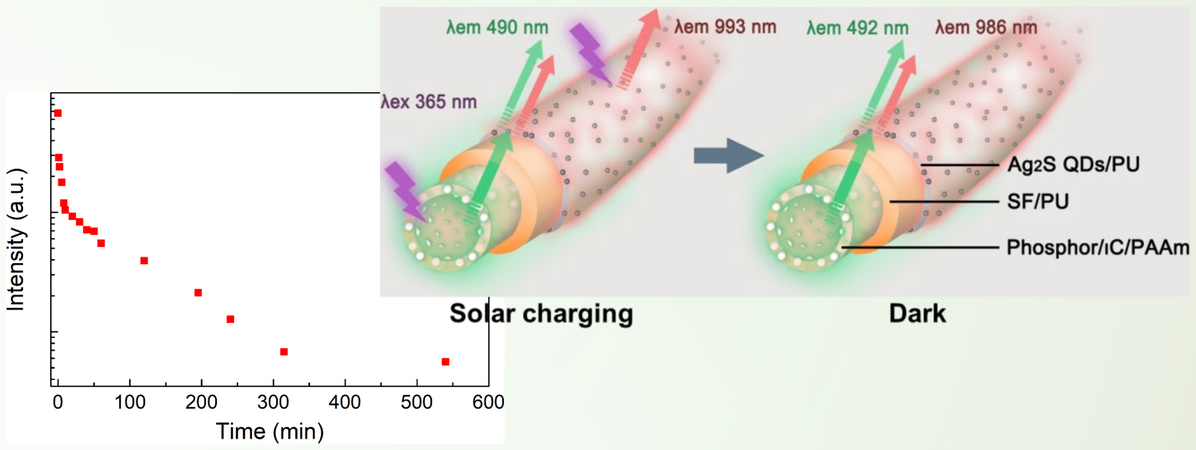
Surface (i) and cross section (ii) morphologies of the solar energy storage fibers with different layers of Ag2S/PU: (A) AS-0, (B) AS-1, (C) AS-3, and (D) AS-5.

Solar Energy Storage & Release by Core-sheath Silk



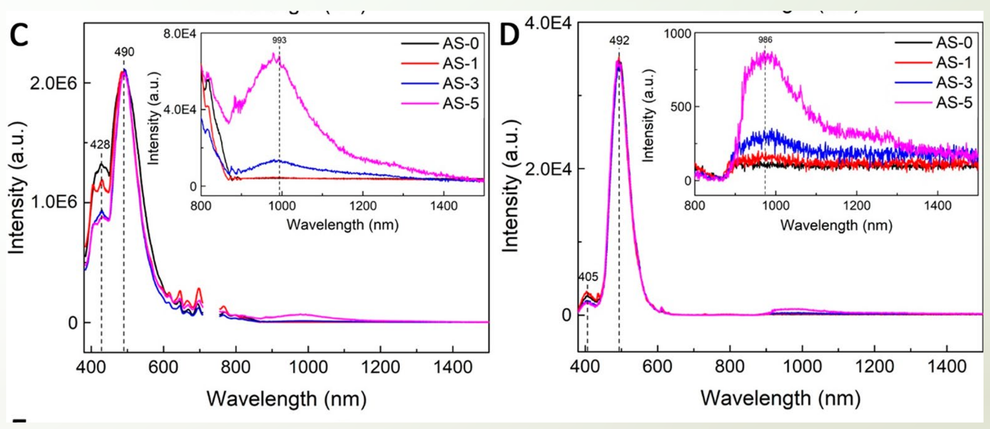
The solar energy fibres (AS-5) in daylight (upper row) and darkness (lower row): original sample and those after immersion in water, acidic, and alkaline artificial perspirations. Their phosphorescence intensity was not affected by various wetting treatments.

The green phosphorescent light may continue for over 9 hours after being exposed to D65 daylight for 1 hour.

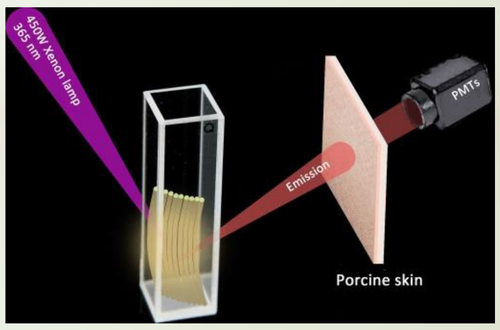


Phosphorescence decay curve of fiber sample AS-0 observed at λem = 492 nm after 1-hour excitation under illuminant D65.

Besides the green emission, NIR emission at 900~1400 nm was detected in the PL spectra of the solar energy storage fibers with different layers of Ag2S/PU under 365 nm excitation (C) and after irradiation (D). Insets show the magnified PL spectra from 800 to 1500 nm.



Summary of Solar Energy Storage Silk



Highlights

- No external circuit or accessory needed
- Continuous PL emission after solar charging
- High flexibility with moderate tensile strength
- Dermal transmittance up to 13.5 % through porcine epidermis (in vitro)

Acknowledgement

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