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MODELLING THE FUTURE

Liquid-Exfoliated SnS_2 for Photothermal Therapy and Nanoelectronics Applications

Nanotechnologies

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Transition Metal Dichalcogenides Nanoflakes produced by Eco-Friendly Liquid-Exfoliation Methods

2D Transition Metal Dichalcogenides (TMDs) are semiconductors with direct bandgaps which absorb photons, making them potential candidates for photothermal therapy and optoelectronics [ref. 1]. They can be fragmented into nanoflakes using liquid-exfoliation. In our study, we introduced two eco-friendly liquid-exfoliation methods for SnS2 nanoflake production: (1) SnS2 powders were ultrasonicated in DI water for over 7 hours (Fig. 1a), and nanoflakes were extracted via centrifugation or filtration (Fig. 1b). (2) We applied electrochemical exfoliation on these SnS2 nanoflakes(Fig. 1c), referencing WS2 phase alterations as reported in the literature. AFM, TEM, EDS, DLS, the absorption spectra and photothermal effect of the ultrasonicated SnS2 and phase-changed SnS2 were investigated.

Nanoflake agents for Near Infrared (NIR) Photothermal Therapy

- **NIR Photothermal Effect: (Fig. 2a)**
  Under 30 minutes exposure of NIR LEDs (Fig. 1e), the ultrasonicated 1mg/mL SnS2(aq) exhibited a temperature rise of 5.9°C. In contrast, the phase-changed 1mg/mL SnS2(aq) obtained an increase of 12.6°C, which is sufficient for hyperthermia treatment on cancer cells (> 43°C is required, a deviation of 6°C from the average human body temperature of 37°C.)
- **Size and Optical Characterization: (Fig. 2b, 2c)**
  AFM images show that the SnS2 nanoflakes were synthesized with a lateral size < 500nm and a thickness < 30nm, which are suitable to be applied on tumor tissue. After electrochemical exfoliation, there were observable changes in both the color and absorption spectra (Fig. 1b, 1d, 2b), suggesting phase alterations which will be further confirmed using STEM.

Conclusion and Outlook

SnS2 nanoflakes were successfully produced using eco-friendly liquid-exfoliation, demonstrating excellent photothermal effect for cancer therapy. We are in the progress of using Langmuir–Blodgett trough to make continuous SnS2 thin films for electronic devices such as photodetectors or memristors.

Figure 1: (a-d) Liquid exfoliation processes (e) NIR exposure test

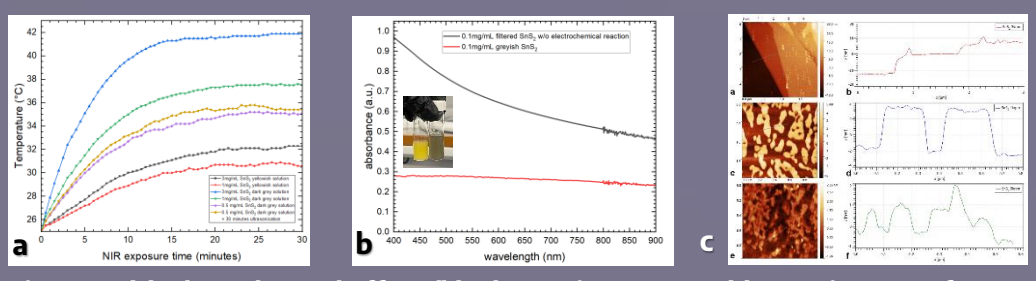

Figure 2: (a) Photothermal effect (b) Absorption spectra (c) AFM images of SnS2 nanoflakes

Reference

[1] Silva, F. A. L. S., Chang, H-P, Incorvia, J. A., Oliveira, M. J., Sarmento, B. Santos, S. G, Magalhães, F. D., Pinto, A. M. 2D nanomaterials and their drug conjugates for phototherapy and magnetic hyperthermia therapy of cancer and infections. *Small*, **(2023)**. (Accepted)

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