UT AUSTIN PORTUGAL ANNUAL CONFERENCE 2023
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Nanotechnology

Optimization of tungsten disulfide production for cancer phototherapy applications

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Introduction

Tungsten disulfide (WS_2) has received much attention, especially for its high absorption in near-infrared regions, along with its high surface area and good biocompatibility. Furthermore, WS_2 possesses high photothermal conversion efficiency, important for photothermal therapy (PTT) applications, namely for cancer treatment. Thus, WS_2 is an excellent candidate as a PTT agent.

WS_2 can be produced by top-down and bottom-up approaches. Top-down methods consist of bulk material exfoliation and size reduction to achieve nanosized single or few layer nanosheets. For biomedical applications, particles with lateral nanoscale dimensions are desired, due to presenting better water stability, biocompatibility, biodegradability, elimination, and better internalization through biological membranes.

Aim and Methodology

WS_2 was produced following a polyvinylpyrrolidone (PVP)-assisted liquid phase exfoliation method. WS_2 and PVP10 were dispersed in ultrapure water, and kept under mechanical stirring, for 20 h at 4 °C. Subsequently, the dispersion was placed in contact with an industrial-grade ultrasound probe using a recirculation system.

This system based on ultrasonication of the material under water recirculation, at a low monitored temperature, allowed for long processing times of large batches. The effect of ultrasonication time on WS_2 lateral size and number of layers, and its impact on particle morphology, water stability, and photothermal properties has been evaluated, to determine the potential of the new small nanosized material obtained for use in photothermal therapy of cancer.

Results

- All samples were stable in water for a week
- WS_2 particle size decreases over time
- WS_2 8h presented a 1.98-fold increase in absorbance in the NIR region
- WS_2 8h presents a typical EDS spectrum and a high thermal stability
- WS_2 8h increased temperature to 53 °C, after 30 min NIR irradiation

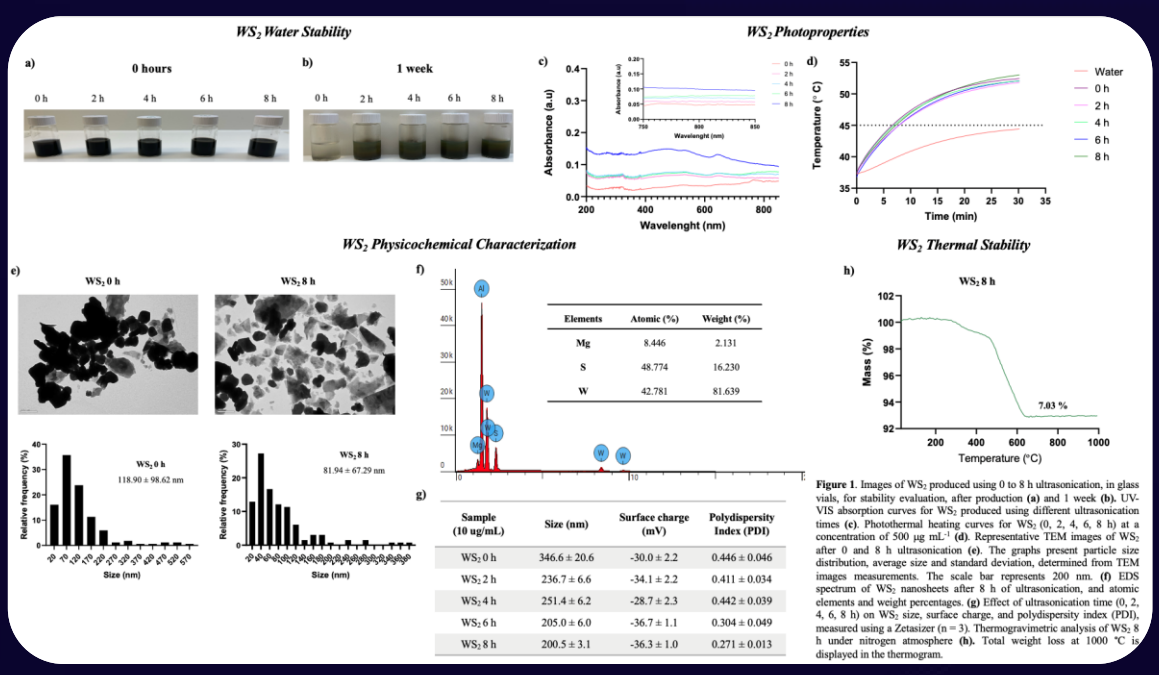

Figure 1. Images of WS_2 produced using 0 to 8 h ultrasonication, in glass vials, for stability evaluation, after production **(a)** and 1 week **(b).** UV-VIS absorption curves for WS_2 produced using different ultrasonication times **(c)**. Photothermal heating curves for WS_2 (0, 2, 4, 6, 8 h) at a concentration of 500 µg mL^{-1} **(d).** Representative TEM images of WS_2 after 0 and 8 h ultrasonication **(e)**. The graphs present particle size distribution, average size and standard deviation, determined from TEM images measurements. The scale bar represents 200 nm. **(f)** EDS spectrum of WS_2 nanosheets after 8 h of ultrasonication, and atomic elements and weight percentages. **(g)** Effect of ultrasonication time (0, 2, 4, 6, 8 h) on WS_2 size, surface charge, and polydispersity index (PDI), measured using a Zetasizer (n = 3). Thermogravimetric analysis of WS_2 8 h under nitrogen atmosphere **(h).** Total weight loss at 1000 °C is displayed in the thermogram.

Acknowledgments

This work was financially supported by LA/P/0045/2020 (ALiCE), UIDB/00511/2020 and UIDP/00511/2020 (LEPABE), UIDB/QUI/00616/2020 (CQVR), funded by national funds through FCT/MCTES (PIDDAC), base UIDB/04293/2020 Funding of the Institute for Research and Innovation in Health—i3S. This work was financed by FEDER funds through the COMPETE 2020—Operational Programme for Competitiveness and Internationalization (POCI), Portugal 2020. This work is financially supported by national funds through the FCT/MCTES (PIDDAC), under the UT Austin PT Program, under the project UTAP-EXPL/NPN/0044/2021 - 2D-Therapy, also under the FCT project 2022.04494.PTDC - PhotoRect. Project 2SMART—engineered Smart materials for Smart citizens, with reference NORTE-01-0145-FEDER-000054, supported by Norte Portugal Regional Operational Programme (NORTE 2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF). Artur Pinto thanks the Portuguese Foundation for Science and Technology (FCT) for the financial support of his work contract through the Scientific Employment Stimulus—Individual Call—(CEECIND/03908/2017). Filipa Silva (2021.05897.BD) would like to thank FCT and European Social Fund (ESF) for financial support.

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