Electronic Supplementary Material (ESI) for Nanoscale
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Supporting information

Multi-wall Carbon IF-WS_2 Nanoparticles with Improved Thermal Properties

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Experimental section

The IF-WS_2 particles were synthesised in a rotary furnace as shown in **Figure S1**. In a traditional static furnace, the WO_x particles stay still in the reaction tube at high temperature (800-900℃), which leads to sintering and 2H-WS_2 dominating the final products. In the rotary furnace, the reaction quartz tube are rotating and moving during the entire process, forcing turbulent movements of the WO_3 nanoparticles and WS_2 formed, resulting in better separated IF- WS_2 products with minimal agglomerations.

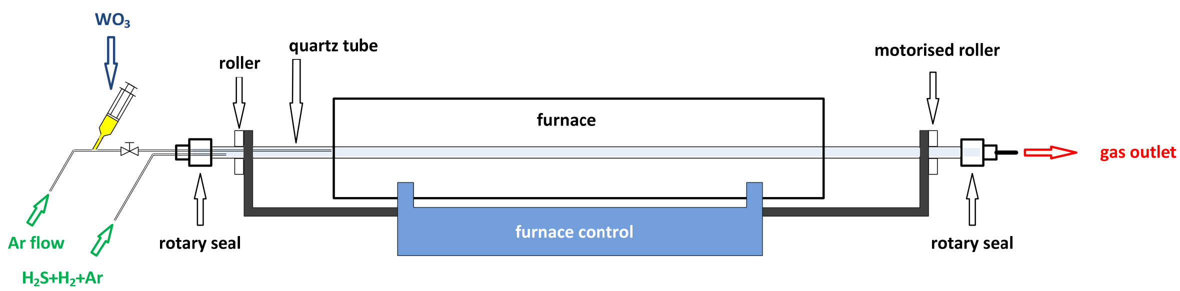

Figure S1 Sketch of the rotary furnace designed for the production of IF-WS_2 nanoparticles

This rotary furnace could run up to 1200°C, with continuously adjustable rotary speeds from 0 to 350 rpm. A feeding system is applied to realise continuous production, which also help to improve the product quality. More details about this patented process will be described somewhere later in another publication.

Results and discussion

A comparison of the XRD profiles of both WS_2 samples is shown in **Figure S2**. Both patterns showed peaks of very similar position. The peaks were assigned according to 2H-WS_2 (JCPDS No. 84-1398)[1]. For the 2H-WS_2, all the peaks detected are very sharp, which indicates a well-crystallized, standard 2H structure, with (002) as the strongest peak, followed by (103) as the second strongest. Compared with 2H-WS_2, the (002) peak of IF-WS_2 is left-shifted, indicating a lattice expansion of (002) layers, *i.e.* 0.62 nm compared to 0.616 nm, due to stains in the curved closed-cage layers [2], and the (103) and (105) peaks are broadened, attributing to ultra-low dimensions. Along with (002) remaining as the strongest peak, two peaks representing (100) and (101) have merged into one peak exhibiting the second highest intensity; also (006) and (104) peaks merged at around 44.1 degree.

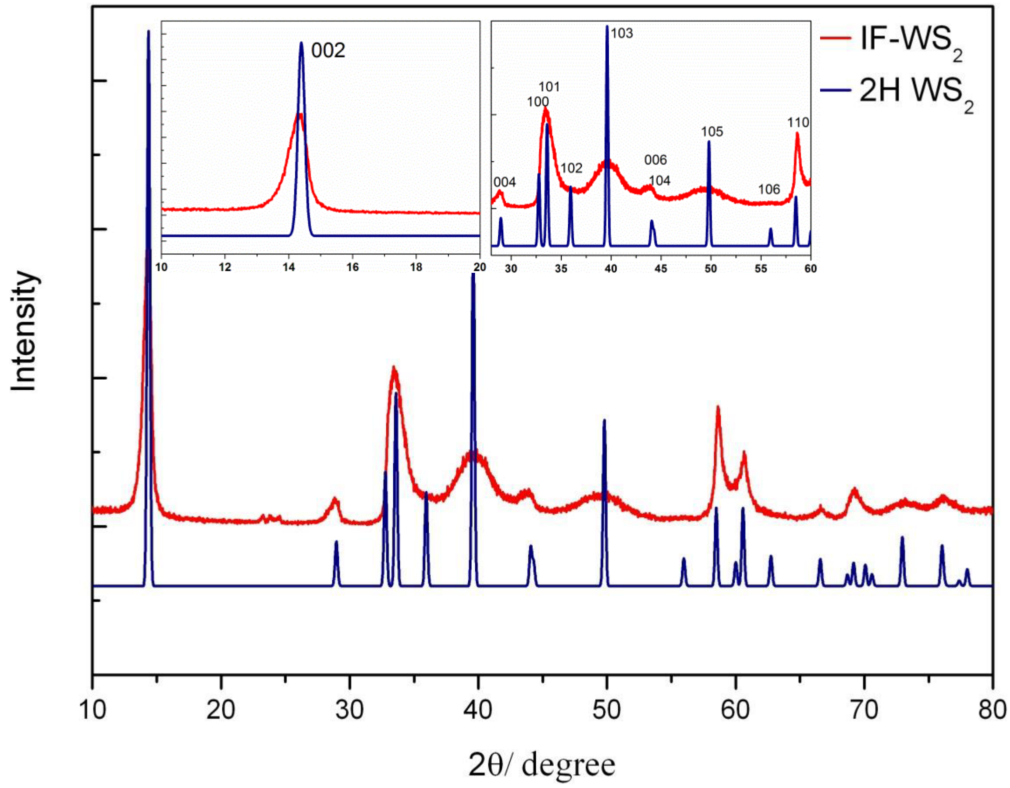

Figure S2 XRD profiles of IF-WS_2 produced by the rotary process and commercial 2H-WS_2

To reveal further details of the suspected carbon peak, a very slow scan at a time step of 20 s was carried out for 2θ angles from 21-30 and 41-50, where the (002) and (100) planes of carbon might appear.

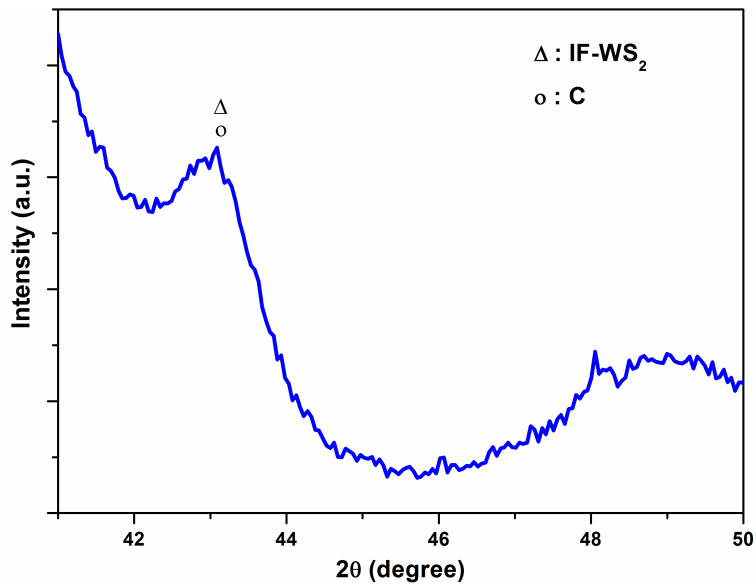

Figure S3 XRD patterns of C-coated IF-WS_2 (41-50°), via a 20 s time step slow scan, to reveal further details of the suspected carbon peak at 41-50, where the (100) peaks of carbon might appear. However, it is difficult to determine whether or not there is a (100) peak for graphite, since the (006) peak for WS_2 also appears at around 43.4°, and they could be overlapped.

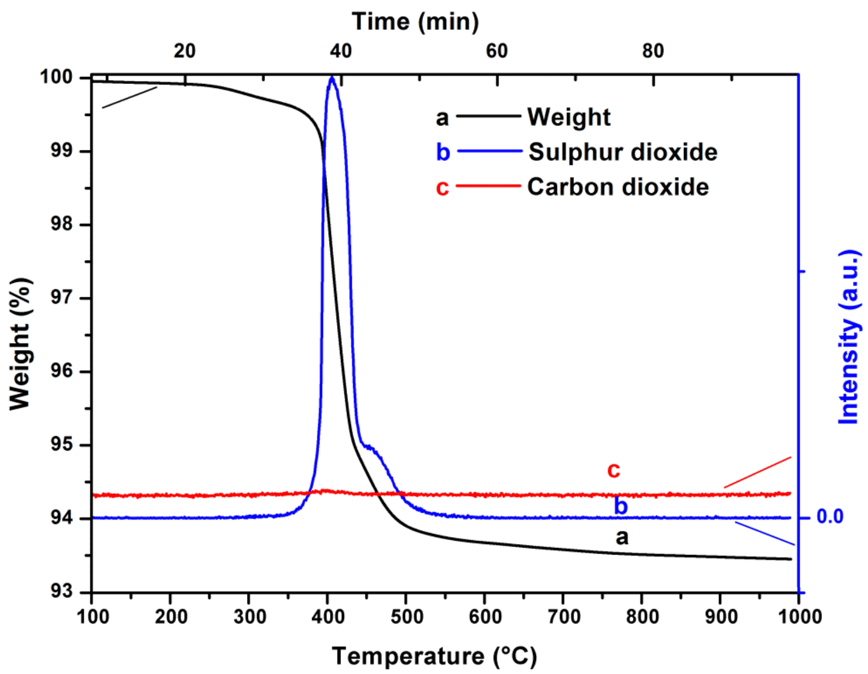

Figure S4 TGA (a) and MS curves for b-SO_2, c-CO_2 of pristine IF-WS_2, conducted in air to 1000°C, with a heating rate of 10°C/min. No distinct CO_2 peak signal is observed during the oxidation of IF-WS_2, and the main peak of SO_2 signal occurred at around 430°C

1. Y. Feldman, G. L. Frey, M. Homyonfer, V. Lyakhovitskaya, L. Margulis, H. Cohen, G. Hodes, J. L. Hutchison and R. Tenne., *J. Am. Chem. Soc.*, **1996**, **118**, 5362-5367.
2. Y. Feldman, E. Wasserman, D. J. Srolovitz and R. Tenne, *Science*, 1995, **267**, 222-225.