Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supplementary information

Oxidation of 2D-WS_2 nanosheets for generation of 2D-WS_2/WO_3 heterostructure and 2D and nanospherical WO_3

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Fig.S1 shows high intensity XRD diffraction patterns of the WS_2 nanosheets before and after drying. Since WS_2 is a hygroscopic material, it absorbs the moisture and physically adsorbed water can be removed by drying at around 100 °C. Here we observed the two unmatched amorphous peaks in our sample between the 2θ of 19-24° before heating. Those peaks were disappeared when the sample was heated for 10-15 minutes at 100 °C.

FE-SEM and corresponding EDS data of the WS_2 nanosheets oxidised at 350°C under DSC mode are shown in the Fig.S2. XRD patterns of the WS_2 nanosheet powders annealed in air for 1 h are given in the Fig.S3. As indicated in the patterns, WS_2 was intact up to 250 °C and was oxidised completely by 350 °C. All the patterns above 250 °C matched with reference file (ICDD PDF number: 04-007-1277) of monoclinic tungsten oxide phase.

The morphological evolution of those WS_2 nanosheets annealed for 1 h in air at different temperatures are shown in Fig. S4 (a-d). The WS_2 nanosheets were intact even after 1 h of holding period at 250 °C (Fig. S4a). Fig. S4b shows the sample heated at 350 °C. WS_2 nanosheets were completely oxidised at 350 °C and transformed into porous oxide nanosheets with rod like monoclinic tungsten oxide particles similar to the features shown in Fig. 7c. Unlike in the DSC samples (continuous heating mode), here the annealed WS_2 nanosheets were completely oxidised at 350 °C due to longer exposure times. Fig. S4 (c&d) indicate

fragmentation of the oxide nanosheets into small agglomerates when the samples were heated at 450 °C and 500 °C, respectively. In these samples, the tungsten oxide rods, as evolved at the initial stage of oxidisation, were found to have grown into cylindrical and/or nearly spherical shaped particle. The measured mean length and width of the particles were around 50 nm and 25 nm, respectively. However, at temperatures above 500 °C, the fraction of nearly spherical particles was found to be higher, which is evident from Fig. 7d.

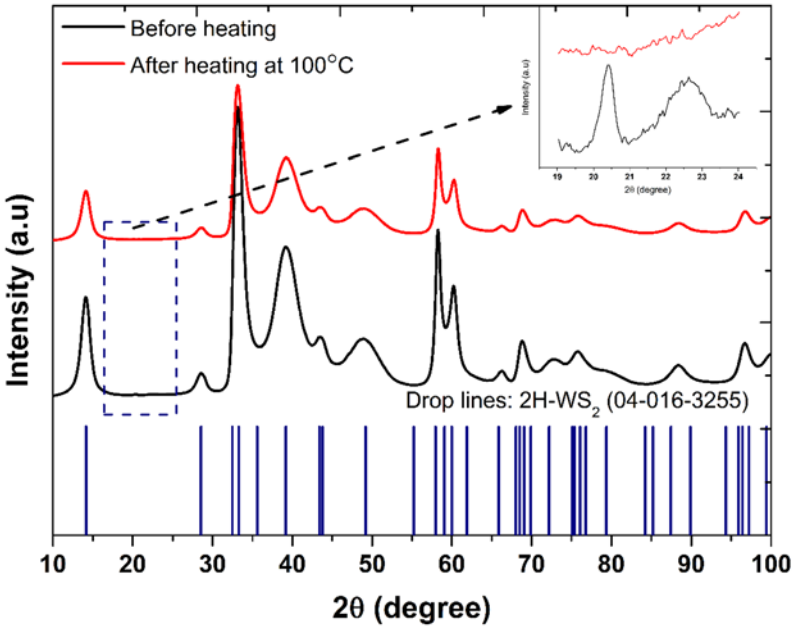
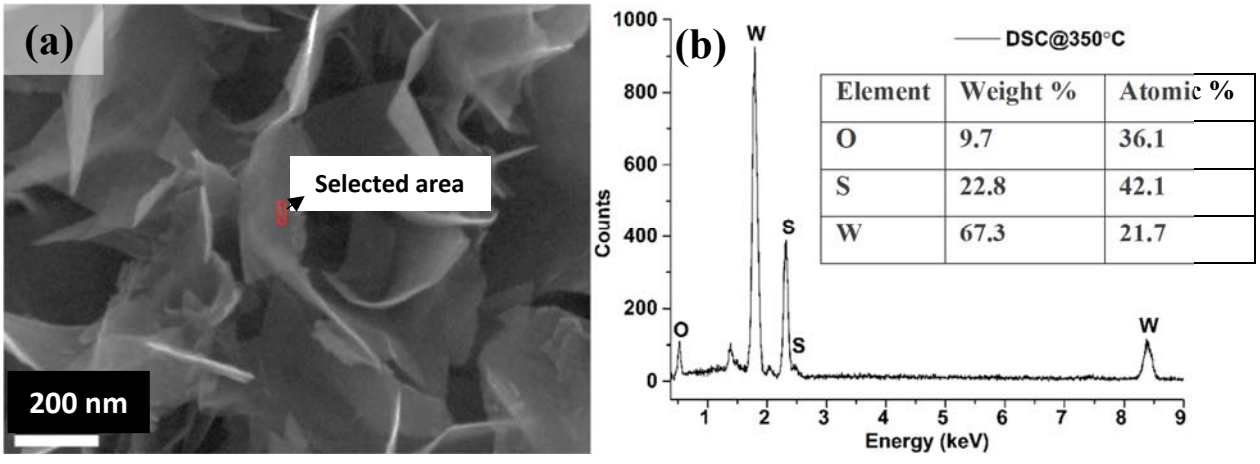


Figure S1: High-intensity micro-area XRD patterns of the as-synthesised 2D-WS_2 before and after heating.



Element	Weight %	Atomic %
O	9.7	36.1
S	22.8	42.1
W	67.3	21.7

Figure S2: FE-SEM-EDS of the sample heated to 350 ℃ in DSC: a) location on the sample from which data was obtained; (b) Corresponding EDS spectrum along with the table of elemental percentages.

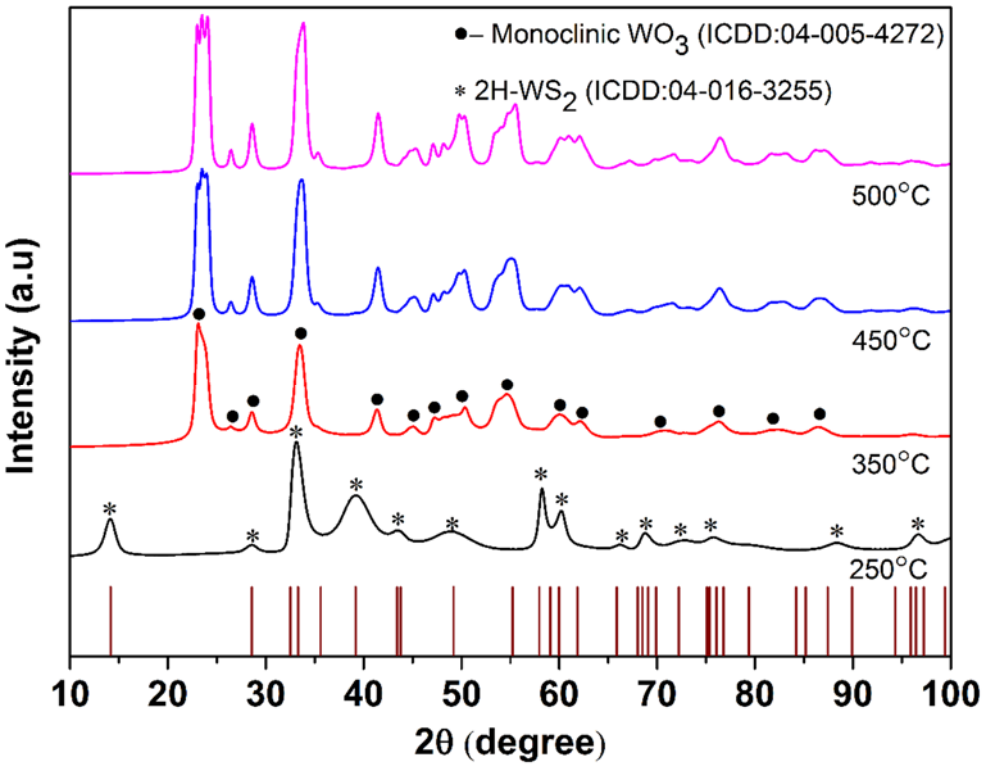


Figure S3: XRD patterns of the 2D-WS_2 nanosheet obtained after heating for 1h at various temperatures in air. Bottom droplines indicate the peak positions from 2H-WS_2 (ICDD: 04-016-3255).

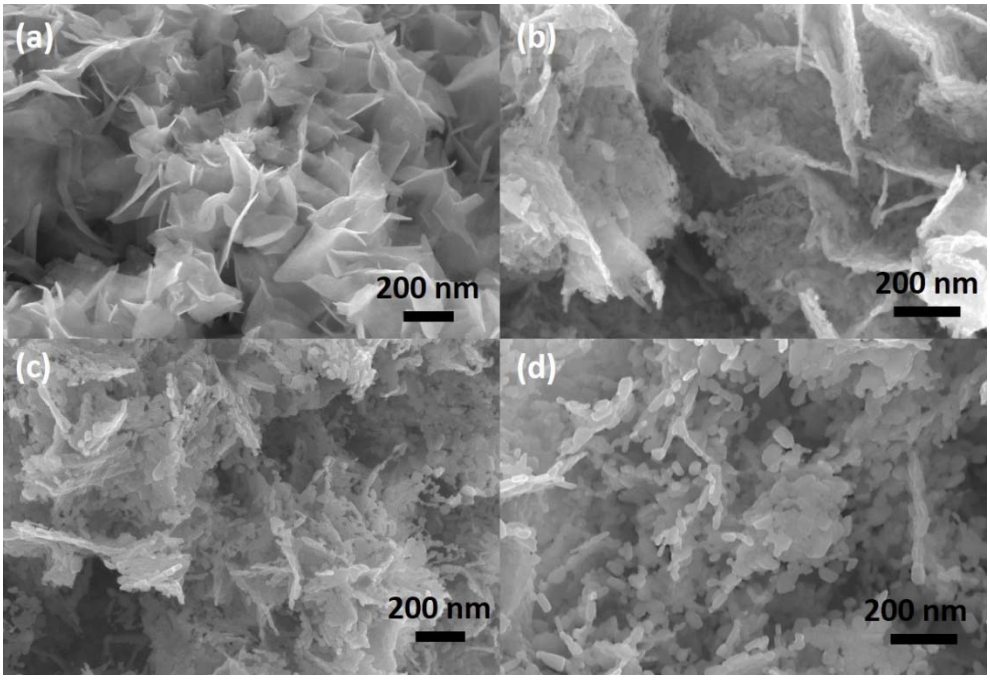


Figure S4: FE-SEM images of WS_2 nanosheets after oxidising in air for 1h (a) 250 ℃ (b) 350 ℃ (c) 450 ℃ and (d) 500 ℃.