

Supporting Information

2D WS₂/Carbon Dot Hybrids with Enhanced Photocatalytic Activity

P Atkin^{a,b}, T Daeneke^a, Y Wang^a, B J Carey^{a,b}, K J Berean^a, R M Clark^{a,b}, J. Z. Ou^a, A Trinchi^b, I S Cole^b and K Kalantar-zadeh^a

^aSchool of Electrical and Computer Engineering, RMIT University, Melbourne, Victoria 3001, Australia. Email: Kourosh.kalantar@rmit.edu.au

^bCSIRO Australia, Private Bag 33, Clayton South MDC, Clayton, Victoria 3169, Australia.

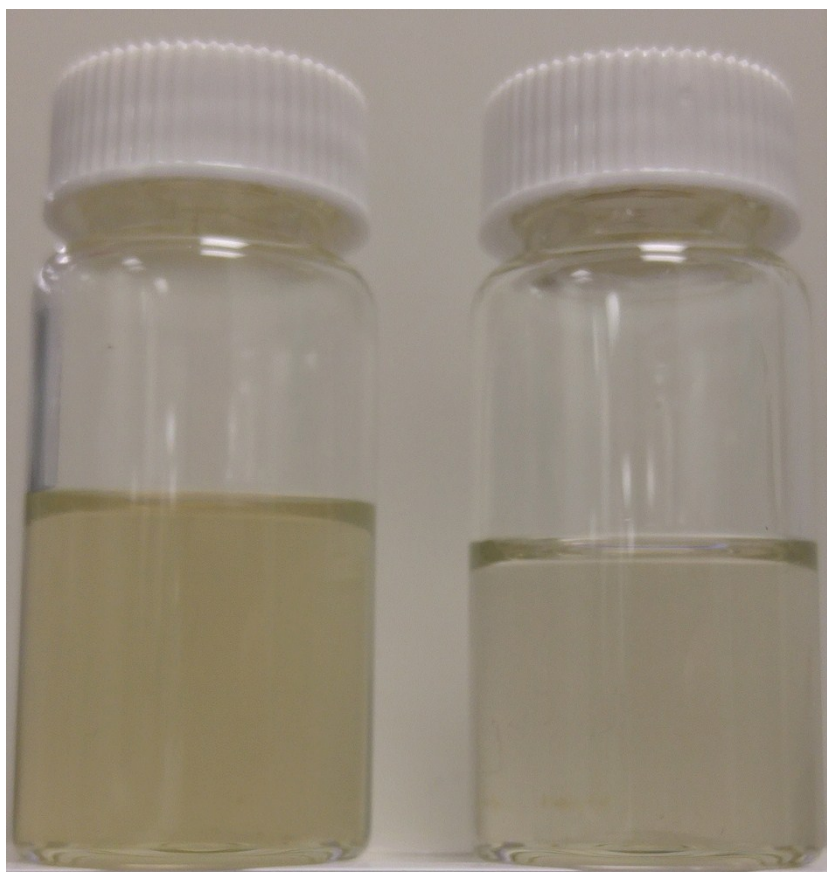


Figure S1: The as-produced pristine 2D WS₂ (left) and the hybrid material (right).

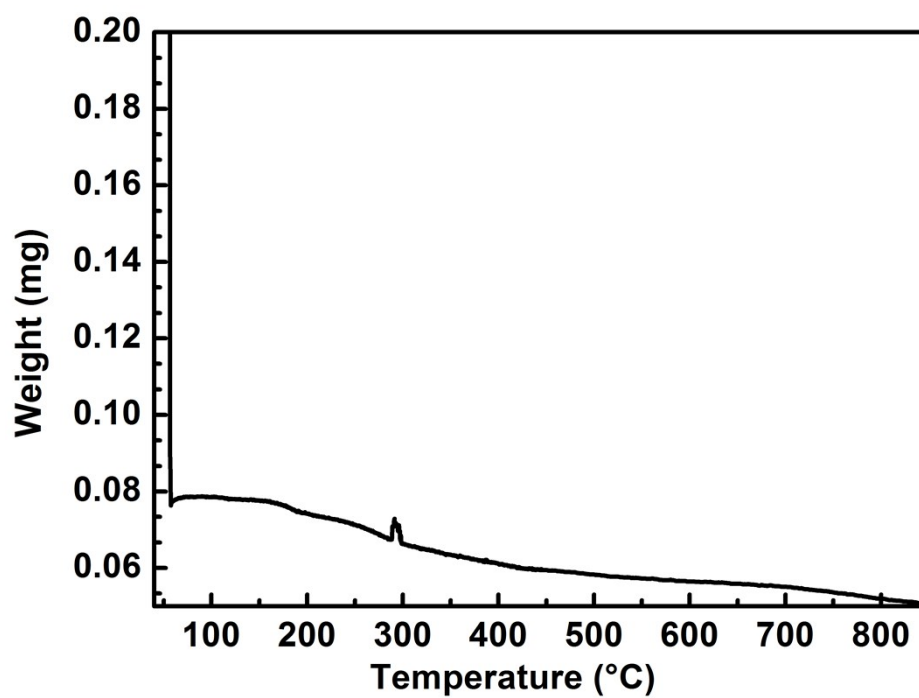


Figure S2: TGA measurement of 50 mL of the as-produced 2D WS₂ solution, from 40°C to 850°C under 20 mL/min nitrogen flow. The weight can be seen to plateau at approximately 0.08 mg, giving a concentration of 1.6 mg/L.

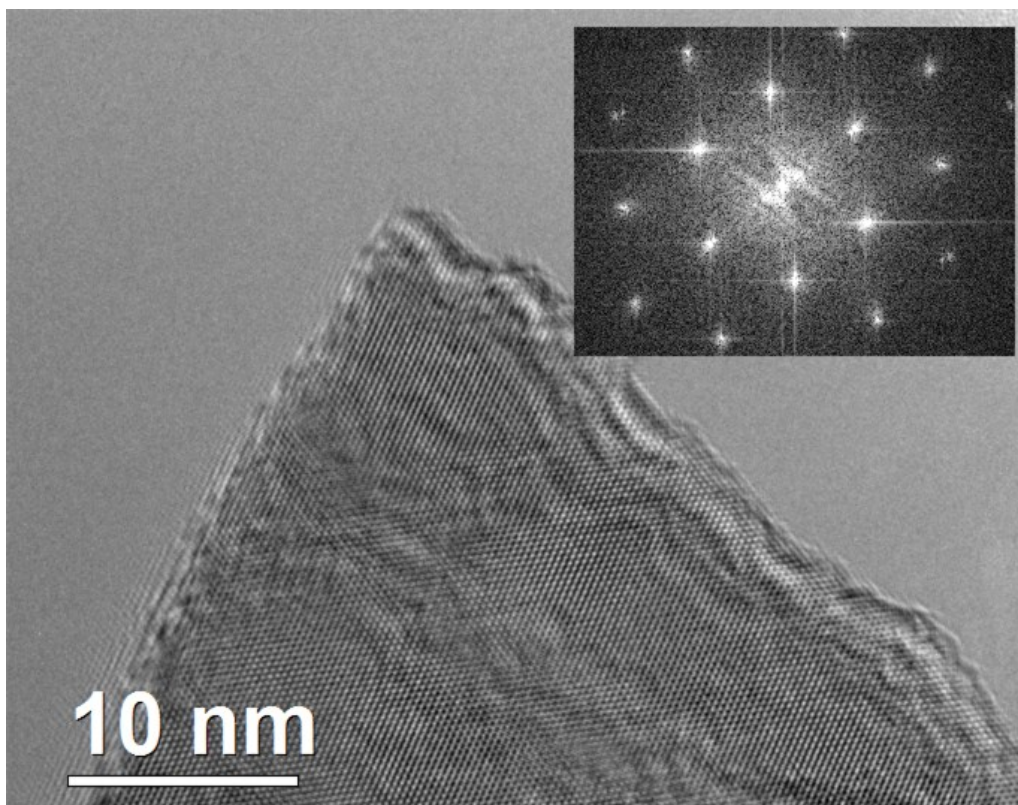


Figure S3: HRTEM of a pristine 2D WS₂ flake following microwave irradiation. No apparent difference can be seen in the appearance or FFT point spacings relative to those of the as-produced 2D WS₂ sample.

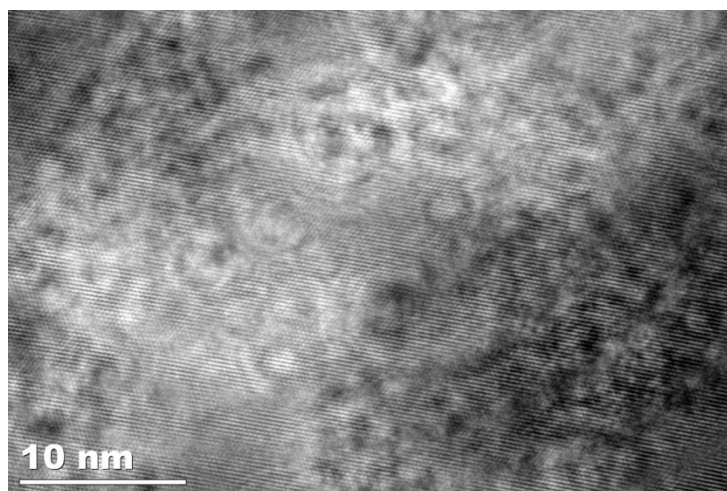


Figure S4: HRTEM of the hybrid material. Although obtaining a clear HRTEM image of CDs of such a small size is inherently difficult, the distribution of CDs on the WS₂ surface can be seen here.

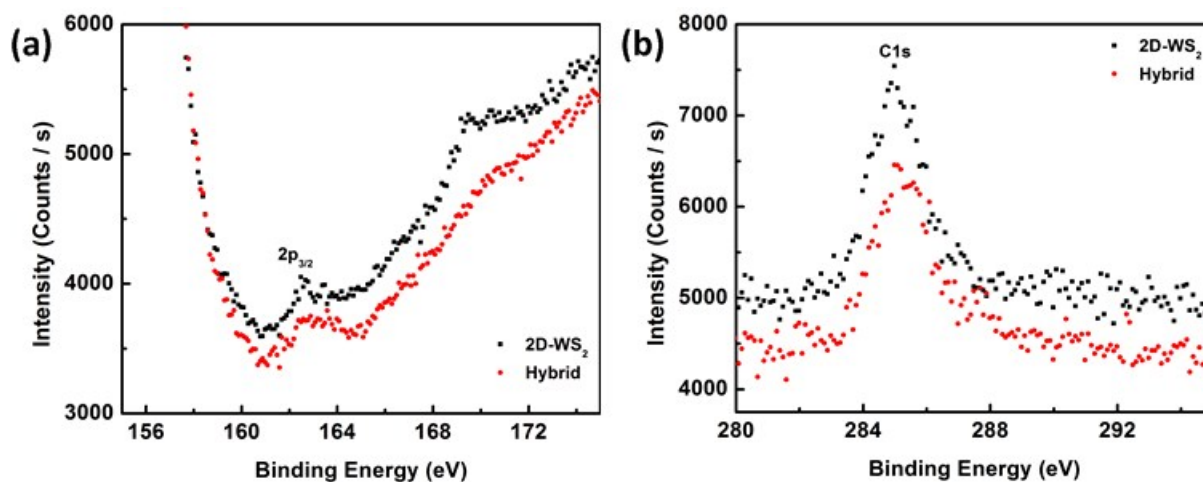


Figure S5: (a) S2p and (b) C1 XPS Spectra. Neither spectrum shows any change between the pristine and hybrid materials other than the formation of oxide peaks, further increasing the likelihood that the inter-material bonding in the hybrid is electrostatic or van der Waals forces rather than covalent.

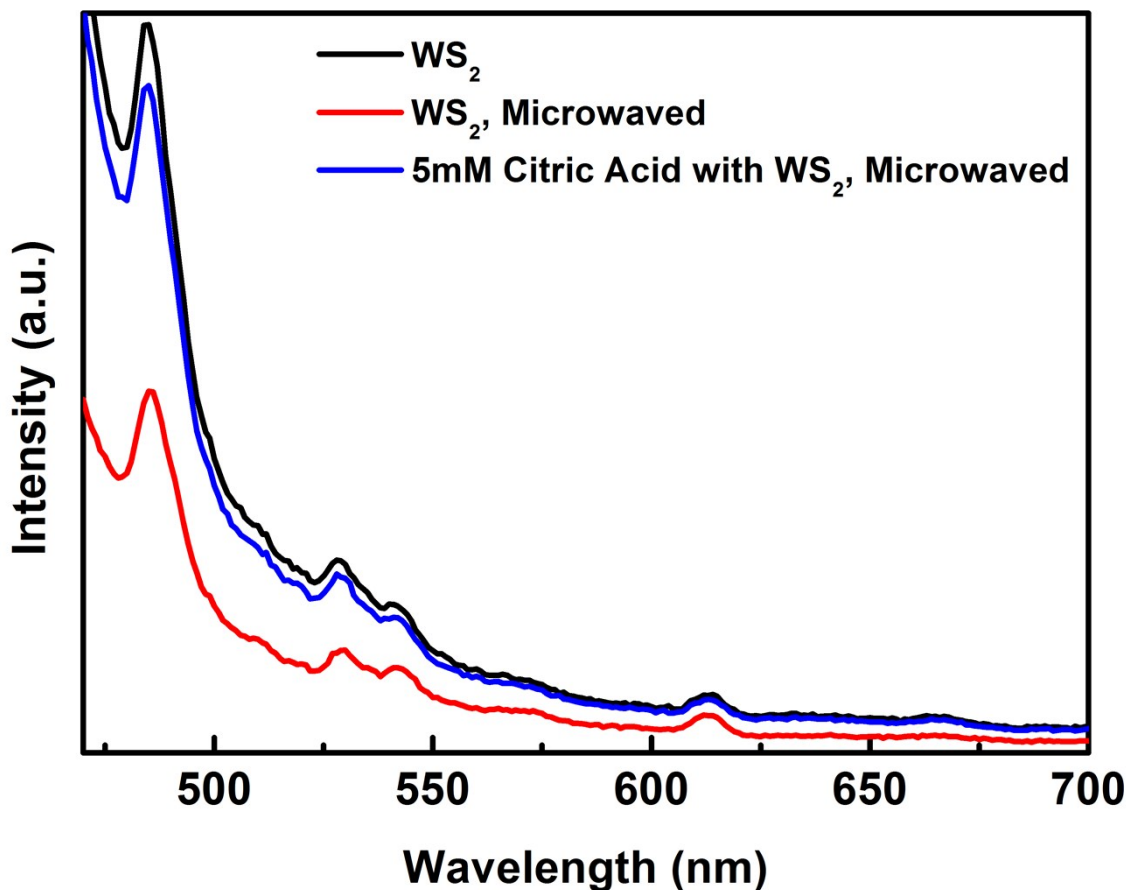


Figure S6: PL spectra of the 2D WS₂ flakes, before and after being irradiated by microwave and after being microwaved in the presence of citric acid. No apparent difference in the PL spectrum can be discerned.

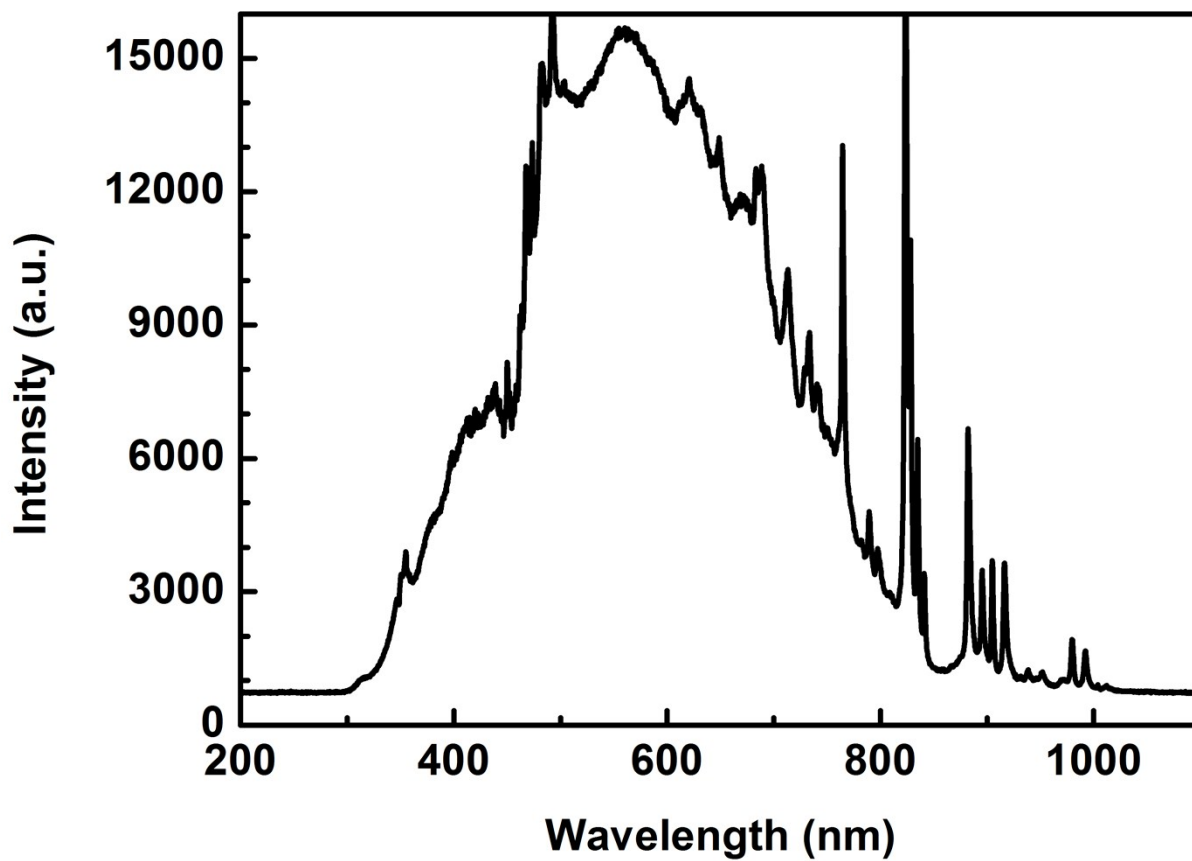


Figure S7: The solar simulator used in the photocatalysis stage of this study was a 150W LS Xenon arc lamp source. The wavelengths and corresponding intensities are presented here.

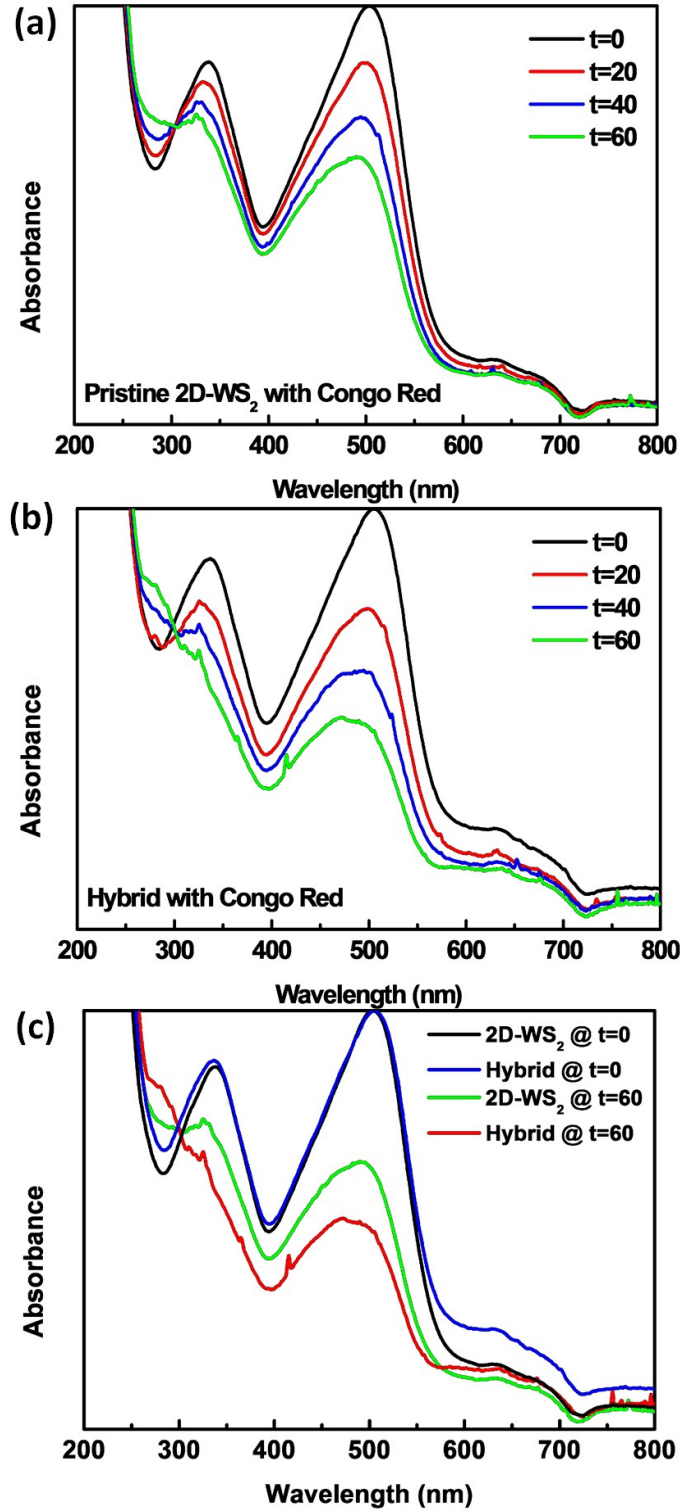


Figure S8: UV-Vis absorbance spectra after elapsed time of 0, 20, 40 and 60 minutes following addition of CR and beginning of exposure to simulated solar light in (a) pristine 2D WS₂ and (b) the hybrid material. In both cases, the intensity of the CR absorbance peaks drops increasingly with longer exposure time, however this rate of change is higher in the case of the hybrid material. This difference can be more clearly seen in (c), where the initial and final spectra of each sample are shown together for comparison.

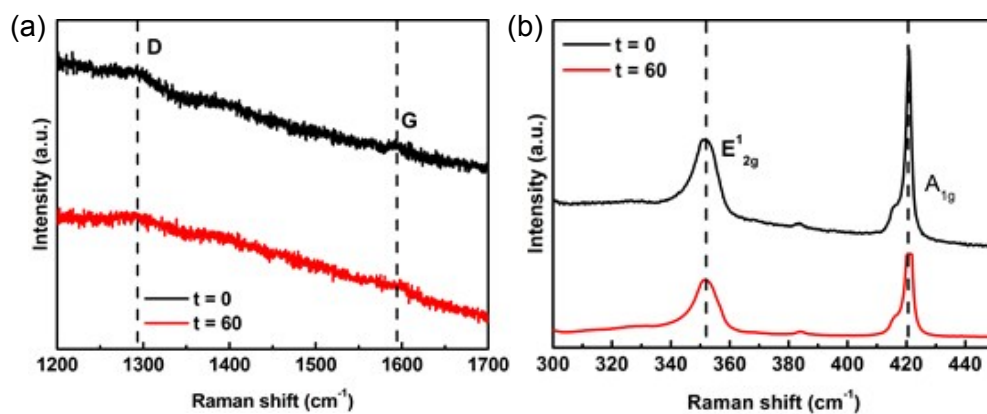


Figure S9: Raman spectra of the hybrid material following its use in photocatalysis. No shift can be observed in the position of the D and G peaks of CD (a) or in either of the major WS₂ peaks (b).

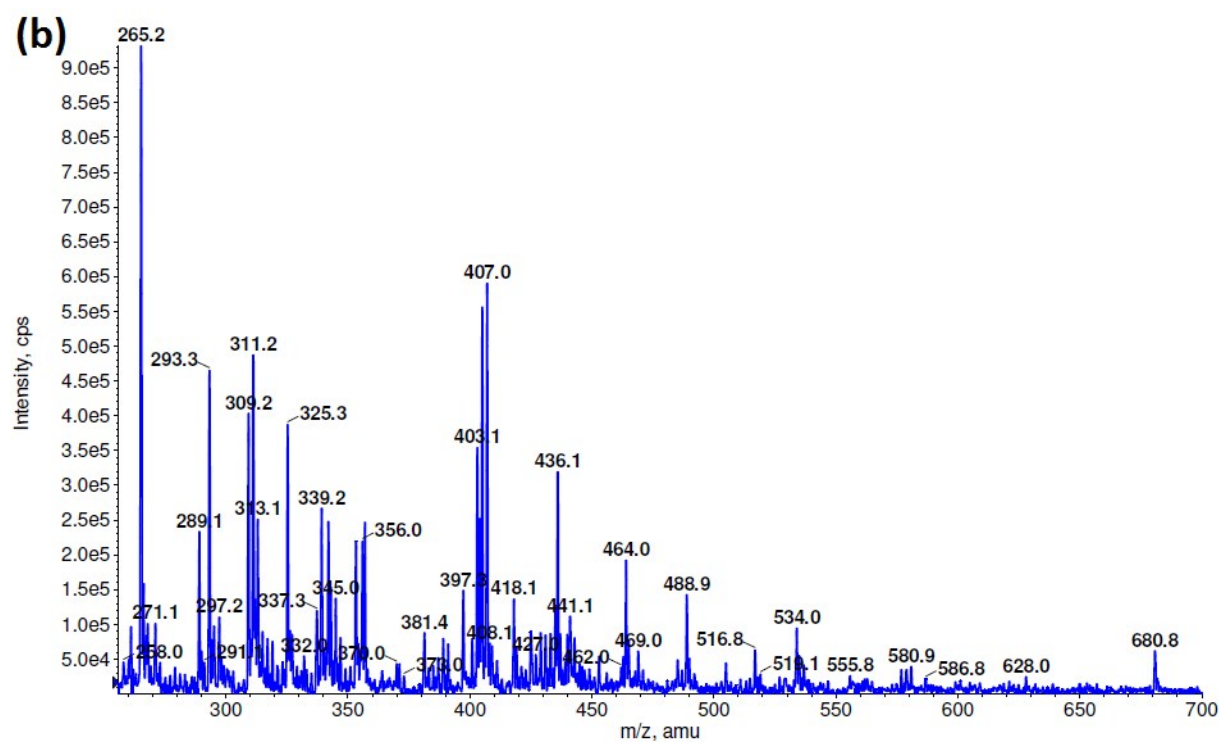
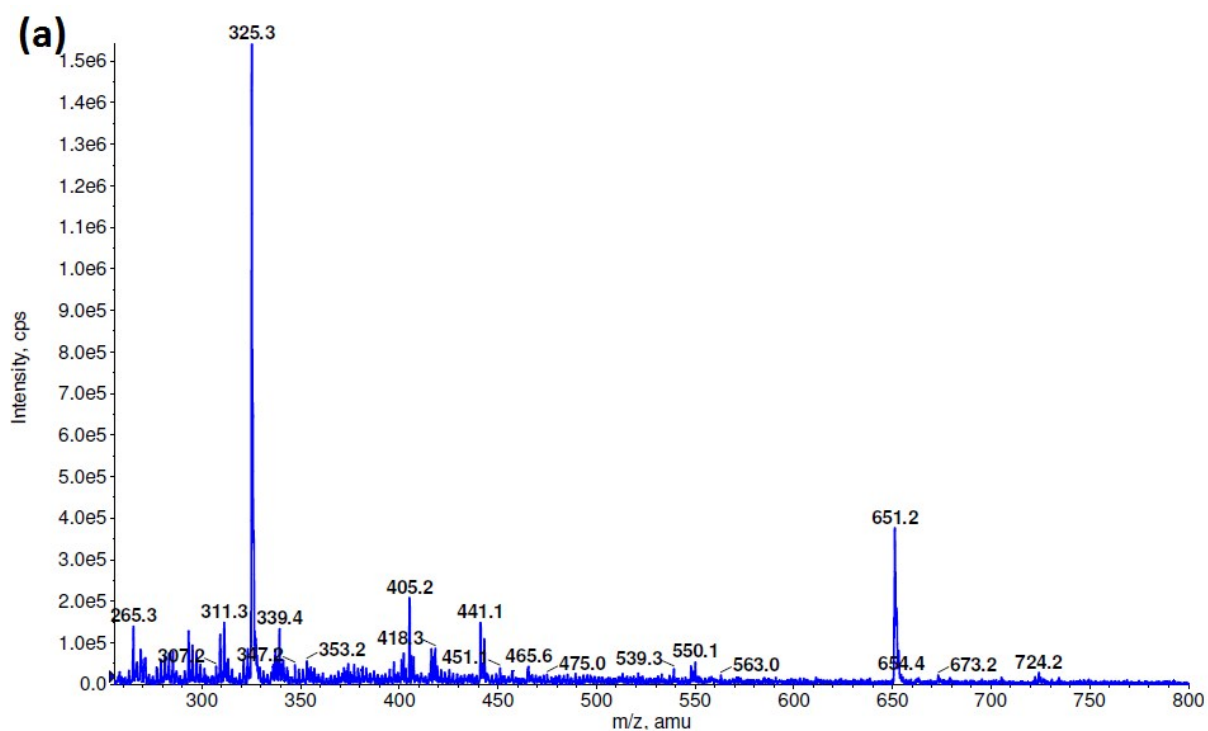


Figure S10: EMS spectra obtained for CR (a) and the photocatalytic degradation products (b).

Table S1: Ionisation potential values of the as measured by PESA.

Sample	Ionisation Potential (eV)
2D WS₂	5.55
Hybrid	5.5
Congo Red	5.26

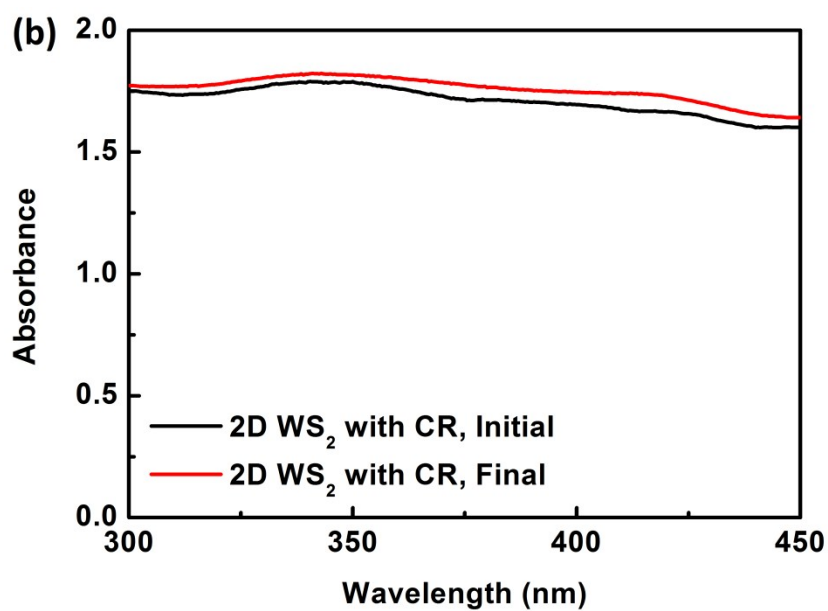
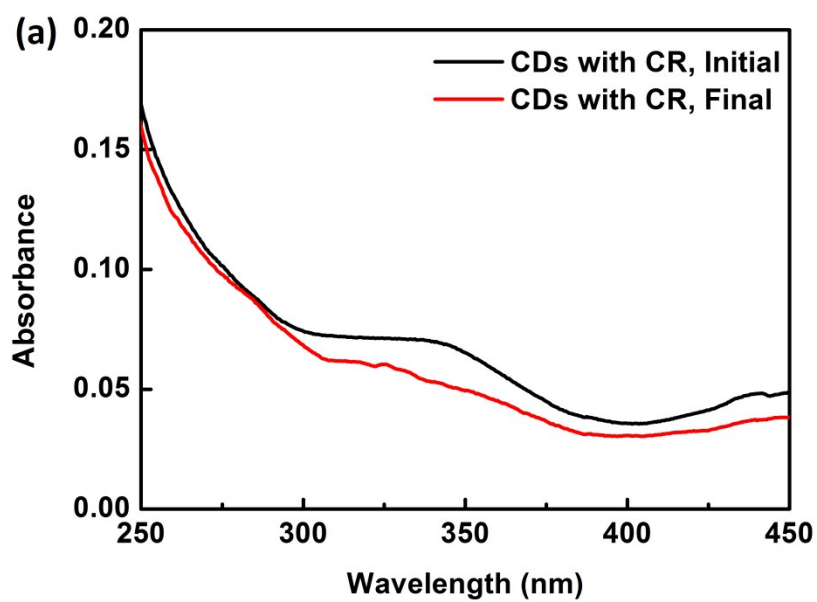


Figure S11: UV-vis spectra of a suspension of CD (a) and WS₂ (B) in the presence of CR. The black spectra indicate measurements directly after mixing the nanomaterials with the dye, the red curves indicate the absorption spectra after stirring the suspension overnight in the dark.

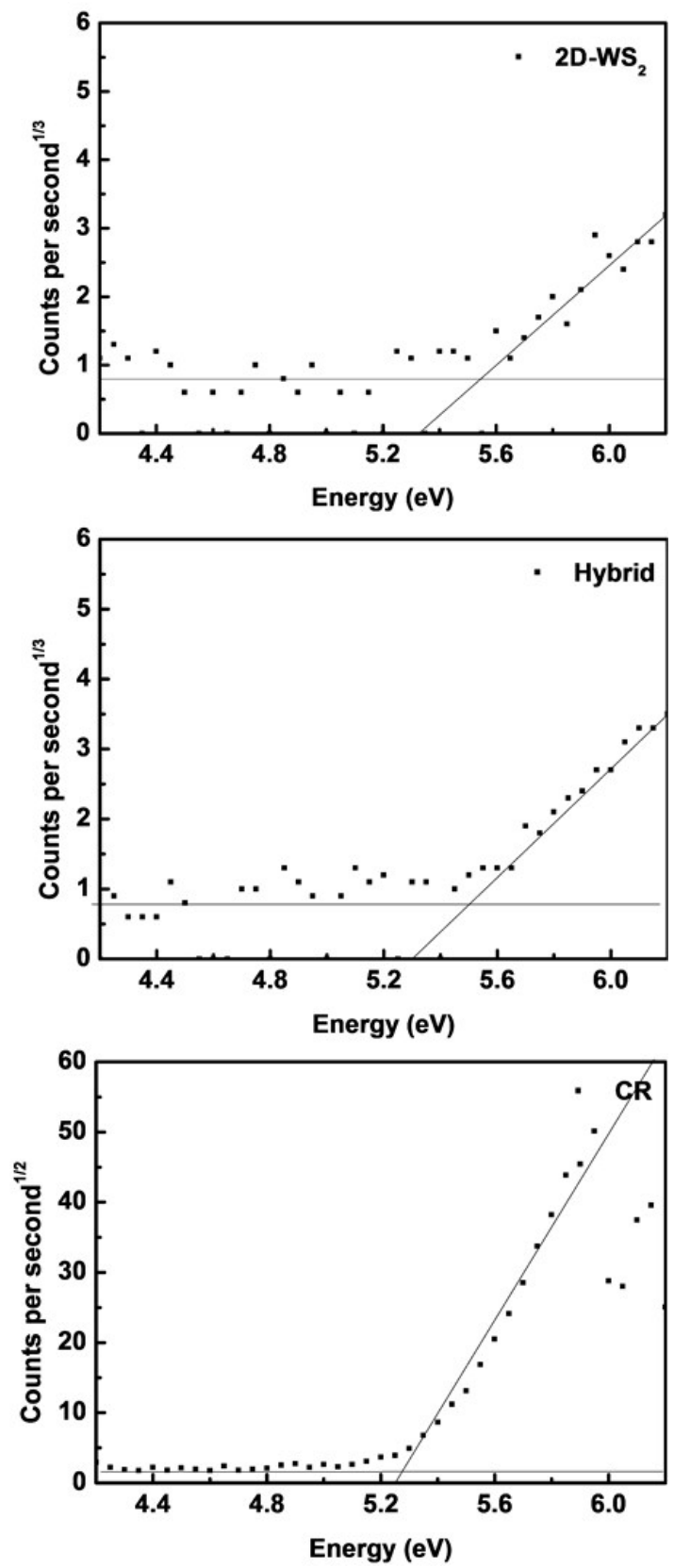


Figure S12: PESA spectra of pristine 2D WS₂, the hybrid material, and CR.