How the Semiconductor Transition Metal Dichalcogenides Replaced Graphene for Enhancing Anticorrosion

Jiheng Ding[§], Hongran Zhao[§], Xinpeng Zhao, Beiyu Xu, Haibin Yu*

Key Laboratory of Marine Materials and Related Technologies, Zhejiang Key Laboratory of Marine Materials and Protective Technologies, Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, Ningbo 315201, P. R. China.

*Corresponding author. E-mail: haibinyu@nimte.ac.cn (Haibin Yu)

[§] Jiheng Ding and Hongran Zhao contributed equally to this work.

Table S1. Chemical composition (wt %) of the Q235 used.

Element	**B**	**C**	**O**	**Si**	**Cr**	**Mn**	**Fe**
Weight%	0.56	5.60	0.45	0.26	0.02	0.43	Bal.

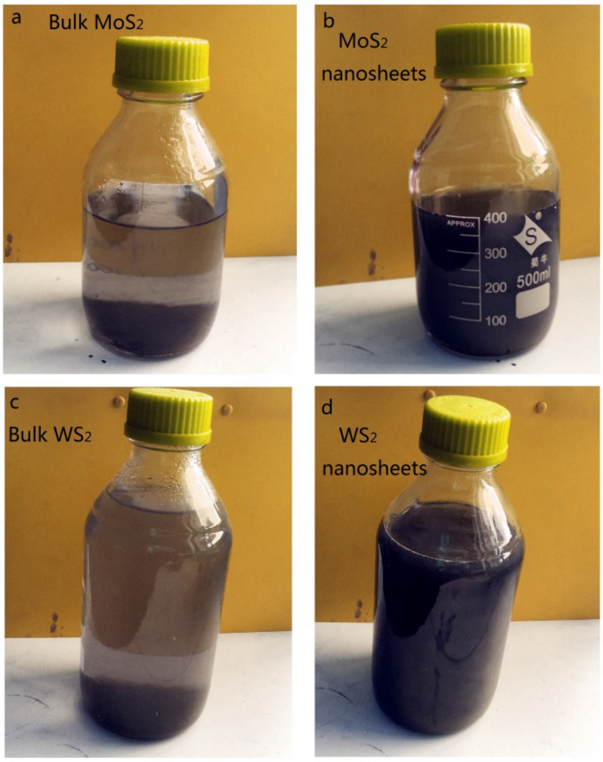

Figure S1. Photos of bulk TMDs and TMDs nanosheets dispersed in NMP for one week.

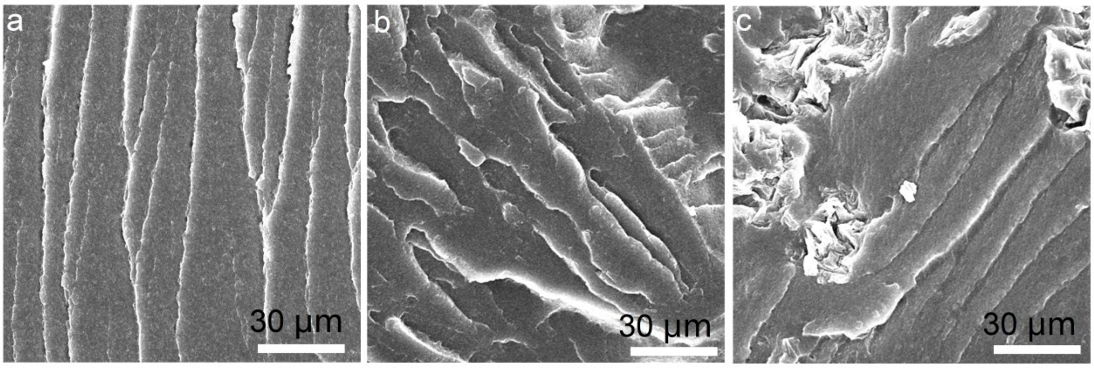

Figure S2. SEM images of pure EP (a), 1.0 wt.% MoS_2/EP (b), and 1.5 wt.% MoS_2/EP (c) coatings, respectively.

The compatibility between the MoS_2 nanosheets and EP matrix was observed by SEM measures of fracture surfaces for different coating systems. For EP coating (Figure S2a), the sample shows obvious brittle fracture with some holes. In Figure S2b, the addition of 1.0 wt.% MoS_2 into EP matrix resulted in rougher fracture surface with sparse and smooth cracks. With the loading of MoS_2 up to 1.5 wt. %, the cross section of the EP matrix formed more holes and messy cracks owing to the aggregated MoS_2 nanosheets.

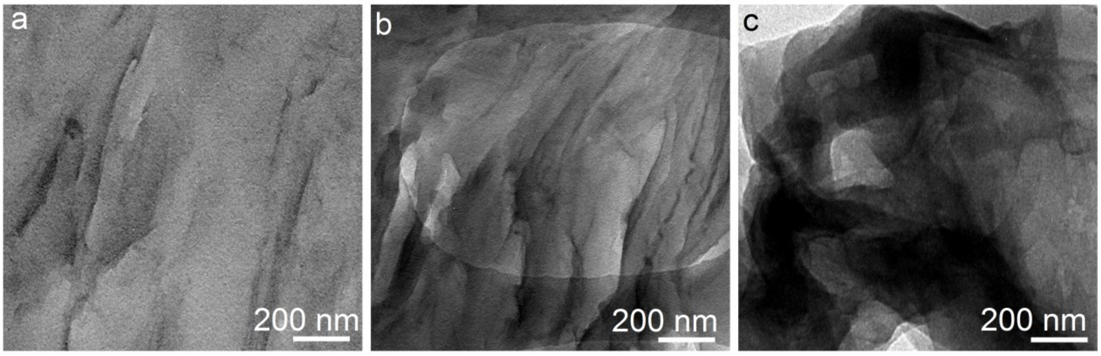

Figure S3. TEM images of1.0wt.% MoS_2/EP (a, b) and 1.5 wt.% MoS_2/EP (c) coatings, respectively.

TEM were used to investigate the dispersion state of MoS_2. The TEM images of MoS_2 dispersed in the EP matrix are shown in Figure S3. It is noted that the gray areas represent the domain of the EP matrix, while the dark lines are the profile of MoS_2 nanosheets. It is clearly observed that the 1.0 wt.% of MoS_2 nanosheets evenly dispersed in the EP matrix (Figure S3a, b). Conversely, serious aggregation of 1.5 wt.% of MoS_2 nanosheets is observed due to the excessive addition. These results confirmed that MoS_2 nanosheets can be dispersed in the EP matrix through a ball milling treatment when the addition of MoS_2 nanosheets was less than 1.0wt.% .

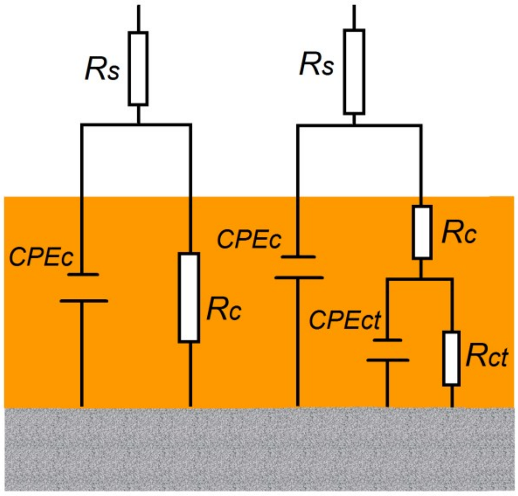

Figure S4. Equivalent electrical circuits.

Table S2. Electrochemical parameters of MoS2/EP coatings

MoS_2 wt.%	Rs/ Ω cm^2	Cc/ 10^{-10} Fcm^{-2}	Rc/ 10^{10} Ω cm^2	Cdl/ 10^{-4} Fcm^{-2}	Rct/ 10^{6} Ω cm^2
0	25.4 ± 3.4	98.9 ± 7.8	$3.3 \pm 0.4\times10^{-5}$	8.76 ± 0.35	3.56 ± 0.33-
0.1	20.6 ± 2.6	39.4 ± 5.6	0.89 ± 0.04	-	-
0.2	27.2 ± 1.9	32.1 ± 5.3	0.96 ± 0.03	-	-
0.3	26.2 ± 5.1	11.4 ± 3.3	1.22 ± 0.20	-	-
0.4	19.4 ± 2.4	9.3 ± 1.2	7.5 ± 0.23	-	-
0.5	21.4 ± 1.7	7.8 ± 2.1	7.9 ± 0.31	-	-
1.0	27.4 ± 1.1	7.3 ± 1.9	8.1 ± 0.24	-	-

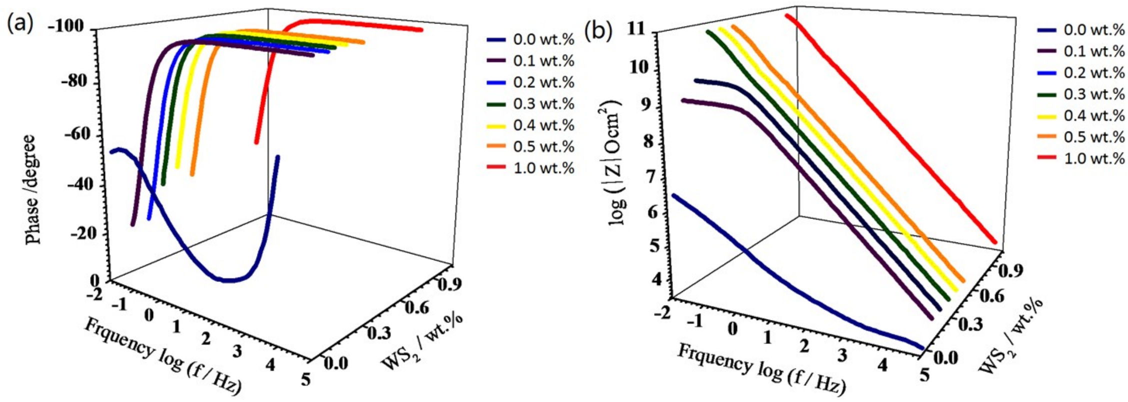

Figure S5. EIS curves of WS_2/EP coatings, (a) Bode phaseplots, (b) Bode-modulusplots.

Table S3. Electrochemical parameters of WS_2/EP coatings

WS_2 wt.%	Rs/ Ω cm^2	Cc/ 10^{-10} Fcm^{-2}	Rc/ 10^{10} Ω cm^2	Cdl/ 10^{-4} Fcm^{-2}	Rct/ 10^{6} Ω cm^2
0	25.4 ± 3.4	98.9 ± 7.8	$3.3 \pm 0.4\times10^{-5}$	8.76 ± 0.35	3.56 ± 0.33-
0.1	16.5 ± 1.5	13.3 ± 2.5	1.2 ± 0.11	-	-
0.2	17.5 ± 2.2	9.2 ± 0.7	2.8 ± 0.46	-	-
0.3	23.4 ± 3.5	8.6 ± 0.5	1.45 ± 0.23	-	-
0.4	22.4 ± 2.9	8.0 ± 0.6	8.6 ± 0.33	-	-
0.5	19.4 ± 3.4	6.9 ± 0.3	8.9 ± 0.43	-	-
1.0	18.9 ± 2.5	6.5± 0.2	9.1 ± 0.29	-	-

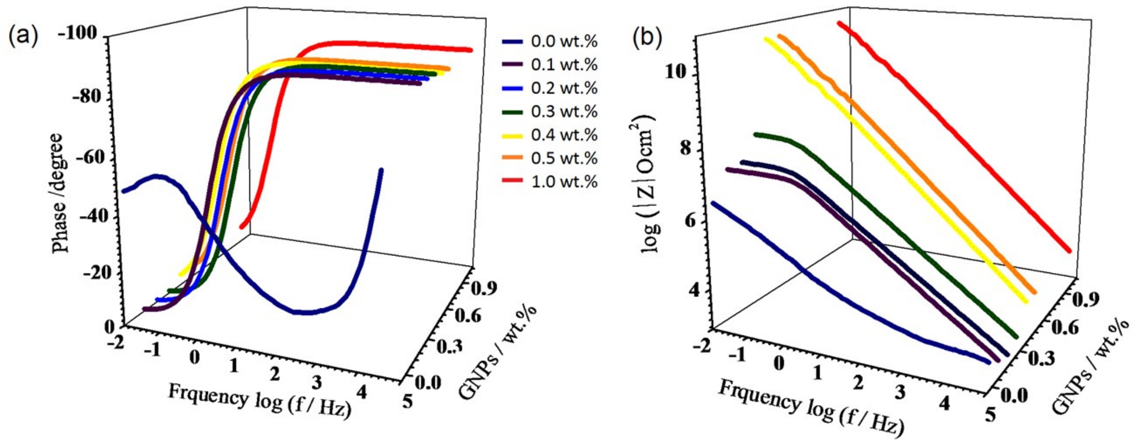

Figure S6. EIS curves of GNSs/EP coatings, (a) Bode phaseplots, (b) Bode-modulusplots.

Table S4. Electrochemical parameters of GNSs/EP coatings

GNSs wt.%	Rs/ Ω cm^2	Cc/ 10^{-10} Fcm^{-2}	Rc/ 10^{10} Ω cm^2	Cdl/ 10^{-4} Fcm^{-2}	Rct/ 10^{6} Ω cm^2
0	25.4 ± 3.4	98.9 ± 7.8	3.3 ± 0.4×10^{-5}	8.76 ± 0.35	3.56 ± 0.33-
0.1	17.9 ± 3.8	27.3 ± 3.7	7.8 ± 0.38×10^{-3}	-	-
0.2	23.3 ± 2.3	7.4 ± 2.3	9.7 ± 0.43×10^{-3}	-	-
0.3	28.2 ± 1.1	7.3 ± 3.7	8.4 ± 0.45×10^{-2}	-	-
0.4	17.2 ± 2.5	6.9 ± 2.9	1.7 ± 0.28	-	-
0.5	23.4 ± 3.7	6.5 ± 2.6	2.3 ± 0.33	-	-
1.0	22.3 ± 3.5	6.8 ± 2.7	2.7 ± 0.41	-	-

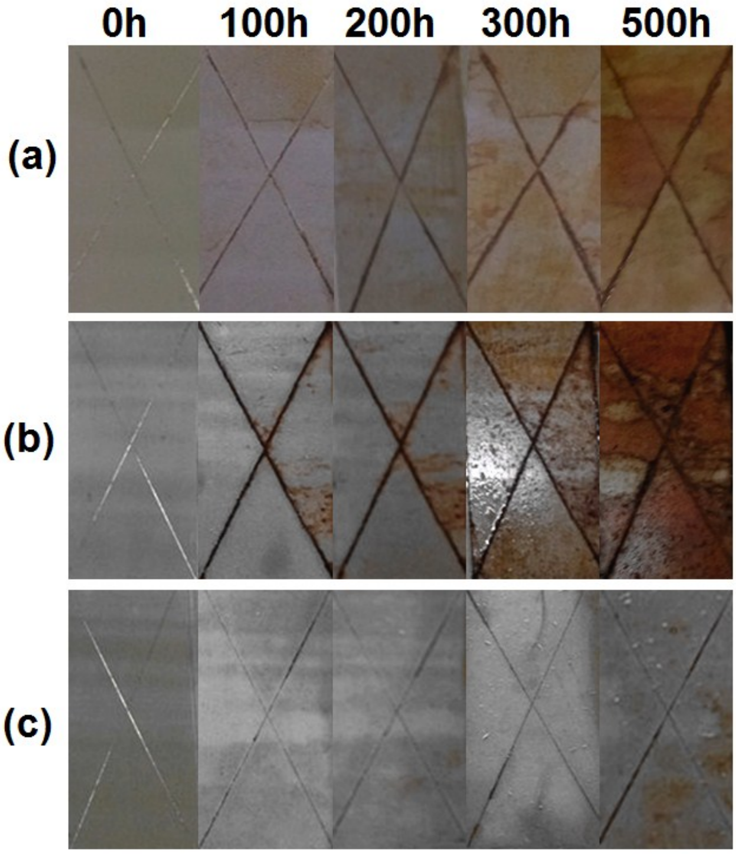

Figure S7. The neutral salt spray tests of NEP (a), 1.0 wt.% GNSs/EP (b), and 1.0 wt.% MoS2/EP (c),respectively.

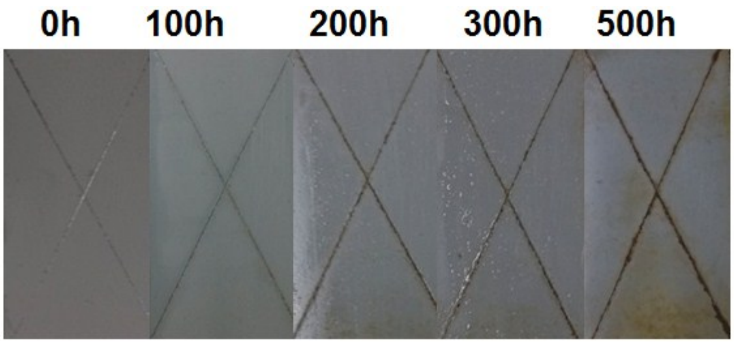

Figure S8. The neutral salt spray tests of 1.0 wt.% WS2/EP.