

# Supplementary Materials

## 1. Materials

Potassium Carbonate ( $K_2CO_3$ ) was supplied by Tianjin Fuchen Chemical Reagent Factory (Tianjin, China). Hydrogen Peroxide ( $H_2O_2$ ) (The concentration of 30%) was purchased from Liaoyang Lulin Chemical Company (Liaoyang, China). Titanium dioxide was purchased from Shanghai Mengmei Chemical Factory (Shanghai, China). Water-soluble imidazoline was supplied by Qingdao Yousuo Chemical Technology Company (Qingdao, China). Ethylene ine Tetra (Methylene Phosphonic Acid) (EDTMPA) was bought from Shandong Huayou Water Treatment Center (Jinan, China). Organosilicon epoxy resin was purchased by Hubei Xinsihai Chemical Company (Xiangyang, China). The ethyl acetate was bought from Huadong Reagent Factory (Shenyang, China). Deionized water was used in the impregnation process. Rust Bullet (SKU: 856084000142) is purchase from Rust Bullet company (Reno, NV, USA).

## 2. Characterization Method

Transmission electron microscope (TEM) was performed using a JEM-1010 instrument supplied by JEOL (Tokyo, Japan). The samples were dispersed in ethanol and placed on a carbon grid for examinations. The surface morphological (SEM) details were studied by scanning electron microscope (Quanta 200, SuZhou Bondray Electronics Technology Co., Ltd., Suzhou, China). X-ray diffraction (XRD) analysis of samples was carried out on a D/max2200 X-ray diffract meter equipped with a  $Cu\ K\alpha$  radiation under the setting conditions of 40 kV and 30 mA. The diffractograms were recorded for  $2\theta$  values ranged from  $10^\circ$  to  $80^\circ$  at a rate of 0.2 s/step. The  $N_2$  adsorption-desorption isotherms were measured by using an automatic NOVA 2000e system (Quantachrome Instruments Corporate Headquarters, Boynton Beach, FL, USA) from Micromeritics. All the samples were outgassed at  $200^\circ C$  until the vacuum pressure was 6 mmHg. The adsorption isotherms for nitrogen were measured at  $-196^\circ C$ . Fourier transform infrared (FT-IR) measurement was using the TENSOR 27 spectrometer (Bruker, Beijing, China) with a  $4\ cm^{-1}$  resolution. TG data were obtained using a thermogravimetry analysis (STA73000, Beijing Sai SiMeng Instruments Co., Ltd., Beijing, China) at a heating rate of  $10^\circ C/min$  in air atmosphere.

The coatings were exposed to 3.5% w/w NaCl solution for 7, 15, 30, 45 and 60 days. Then, the electrochemical impedance spectroscopy (EIS) was utilized in order to investigate the corrosion protection properties of the epoxy coating on the steel substrates with the different multi-functional  $TiO_2(w)$  carrier additive coatings. The experiment was done by an AUTOLAB 86183 at amplitude and frequency range of  $\pm 10\ mV$  and  $100\ kHz-0.01\ Hz$ , respectively. The corrosion potention ( $E_{corr}$ ) of the steel substrate was obtained from the open circuit potential at the equilibrium state of the system. Also, the measurements were performed in a conventional three electrode cell including coated steel specimen as working electrode, Pt wire and saturated calomel electrode (SCE) as counter electrode and reference electrode, respectively. Neutral salt spray test was carried out in a salt spray test chamber according to the standard ASTM B-117 (*Standard Practice for Operating Salt Spray(Fog)Apparatus*; ASTM International; West Conshohocken, United States, 2007). Specimens were exposed to a continuous indirect spray of 5 wt % NaCl aqueous solution (pH 6.5–7.2) at a temperature of  $35^\circ C$ . The fell rate of spray was about  $0.013-0.025\ mL\ cm^{-2}\ h^{-1}$ . The test duration was 45 days. The scale inhibition performance was implemented according to the following method. The coated steel specimens were vertically immersed in same vessels containing 2 L water, which dissolved 0.02 mol  $CaCl_2$  and 0.04 mol  $NaHCO_3$ , without stirring at  $60^\circ C$ . The EIS for the defected samples are treated as follows.

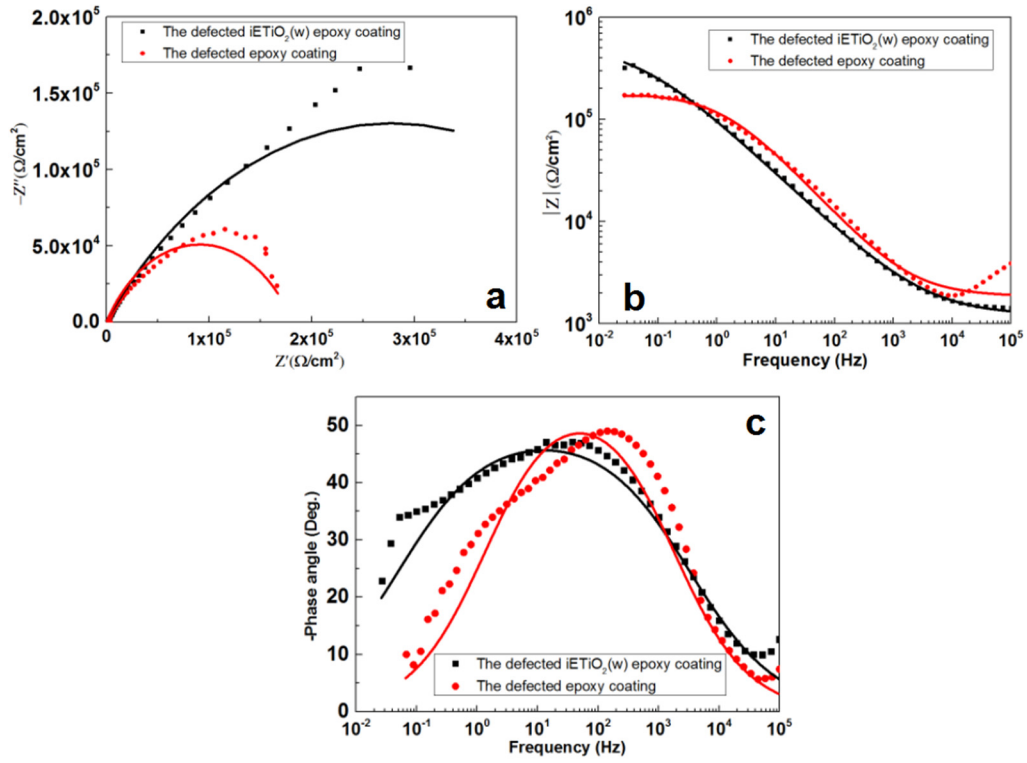
EIS test for the defect sample: The defect is cut by knife with two 1 cm cross the line. The samples were put into the salt spray test chamber for 24 h before the EIS test. A contact-angle meter (JC2000A,

Shanghai, China) is adopted to measure the CA of liquid droplets on the prepared surfaces. The volume of the individual droplet used for the CA measurement is controlled at around 5 L.

Surface roughness profiles are measured by a roughness measuring instrument (178-601, Mitutoyo, Japan).

### 3. Steel Treated Method

The steel plate (1100 grade, 80 mm × 80 mm × 1 mm) was polished with 240 and 800 mesh sand papers in a certain direction, and then ultrasonically in absolute alcohol to remove surface impurities.



**Figure S1.** Nyquist plots (a) of the defected iETiO<sub>2</sub>(w) epoxy coating and the defected pure epoxy coating, Bode plots (b,c) of the defected iETiO<sub>2</sub>(w) epoxy coating and the defected pure epoxy coating.