Electronic Supplementary Material (ESI) for RSC Advances.

Rapid wet-chemical oxidative activation of graphite felt electrodes for vanadium redox flow batteries

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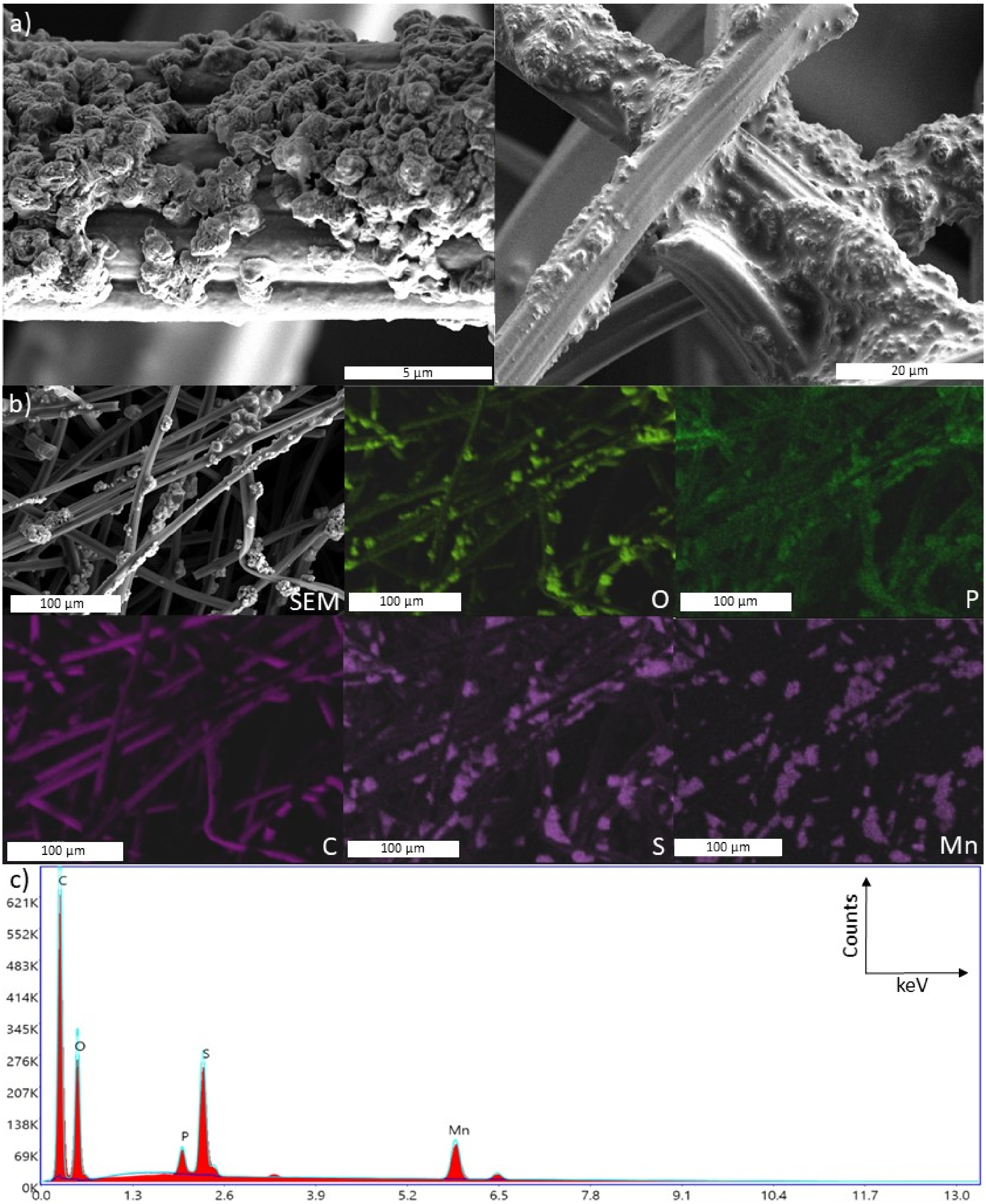

Figure S1: a) SEM imaging of a MnO_x decorated P-GF after step 1 in Figure 1 and b) SEM-EDX mapping of multiple fibers (Top left: Raw SEM image, Top middle: Oxygen, Top left: Phosphorus, Bottom left: Carbon, Bottom middle: Sulfur, Bottom right: Manganese).

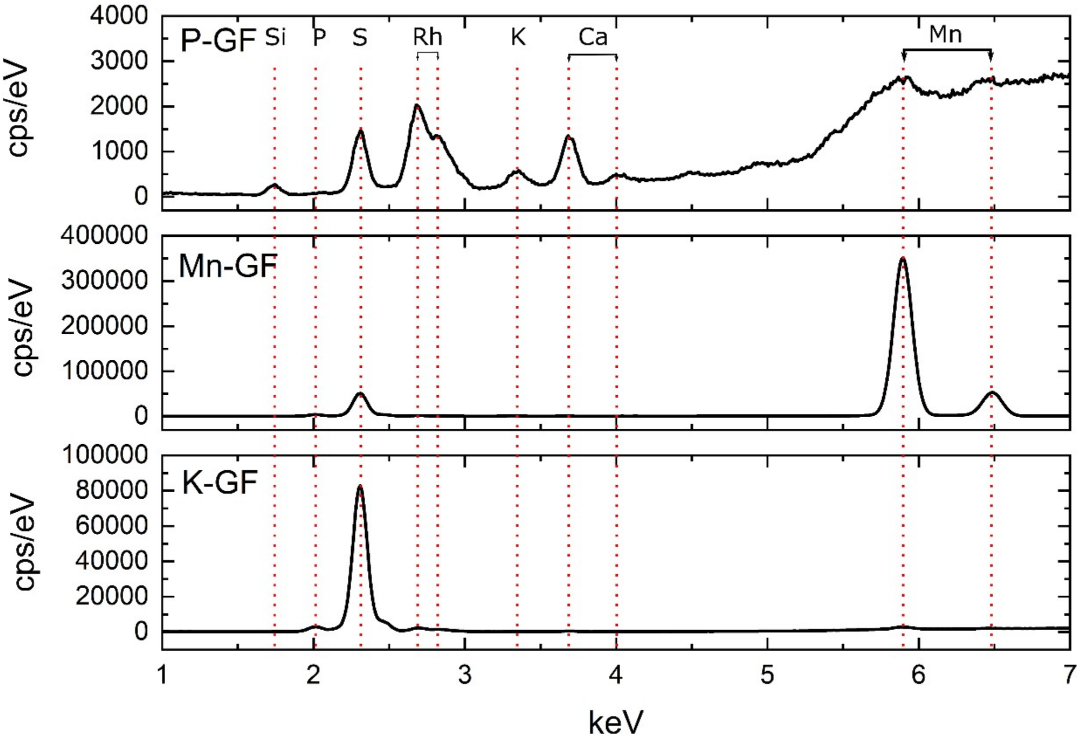

Figure S2: XRF analysis of the P-GF, MnO_x coated GF (denoted as Mn-GF) and the K-GF electrodes. Special attention must be paid to the y-axis scale bar.

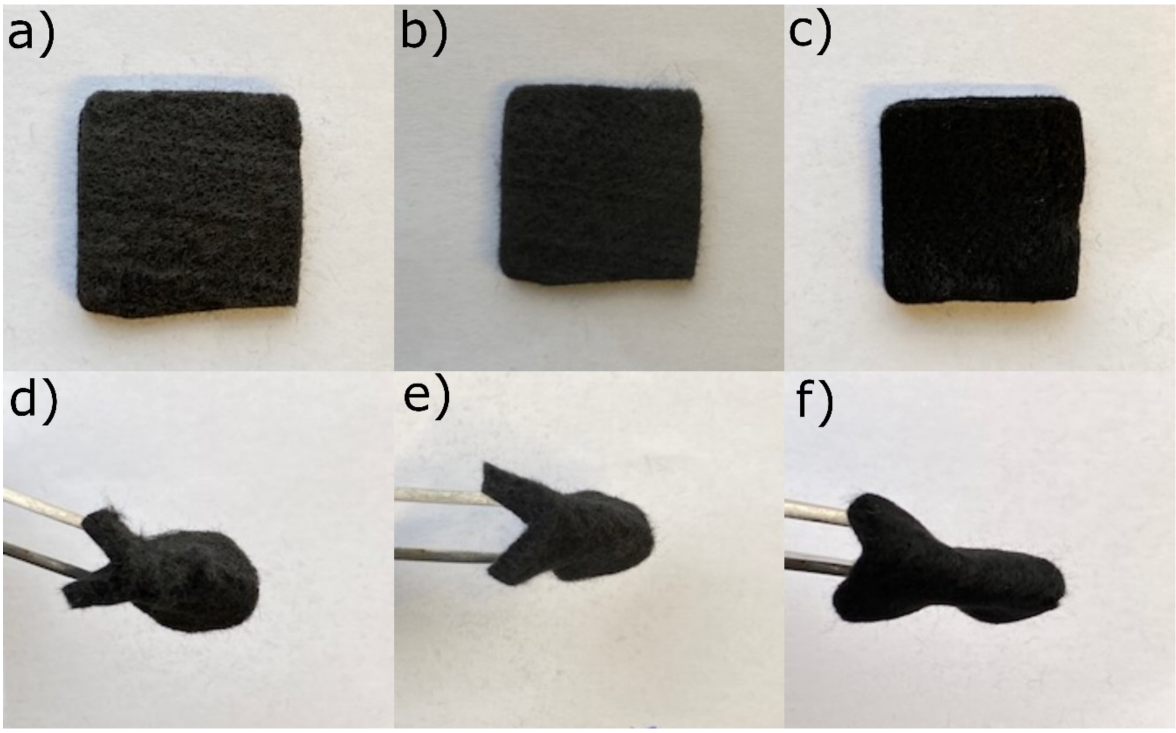

Figure S3: Photographs depicting the physical condition of electrodes used in this study. a) P-GF before treatment, b) T-GF electrode after treatment, c) K-GF electrode after treatment, d) P-GF electrode bent with tweezers, e) T-GF electrode bent by tweezers and f) K-GF electrode bent by tweezers.

*Table S1:Cyclic voltammetry results for the optimization of the KMnO4 treatment process as described in Table 1 and Figure 2. The best result for each testing group is marked with an *.*

Test Number	**Test Type**	$E_{peak\ ox}$ **V**	$E_{peak\ red}$ **V**	ΔE_{peak} **V**	$I_{peak\ ox}$ **A/g**	$I_{peak\ red}$ **A/g**
1*	$KMnO_4$ Conc.	0.880	0.724	0.156	2.69	-3.14
2		0.893	0.687	0.206	2.07	-2.80
3		0.903	0.677	0.226	1.84	-2.57
4	Time	0.908	0.685	0.223	2.58	-3.01
5*		0.873	0.722	0.151	2.99	-3.03
6		0.916	0.682	0.234	2.44	-3.01
7		0.926	0.685	0.241	1.86	-2.85
8		0.920	0.667	0.253	1.78	-2.44
9	Temperature	1.010	0.634	0.376	1.41	-1.54
10		0.889	0.708	0.181	2.11	-3.07
11*		0.882	0.717	0.165	2.75	-3.11
12		0.907	0.698	0.209	2.22	-2.95
13*	Acid	0.873	0.714	0.159	2.51	-3.07
14		0.892	0.710	0.182	2.46	-2.95
15		0.883	0.714	0.169	2.40	-2.94

Figure S4: Contact angle of DI water on the a) P-GF electrode, b) T-GF electrode and b) K-GF electrode. Sample sizes of 1 cm^2 were used and each water droplet volume is 5 µL.

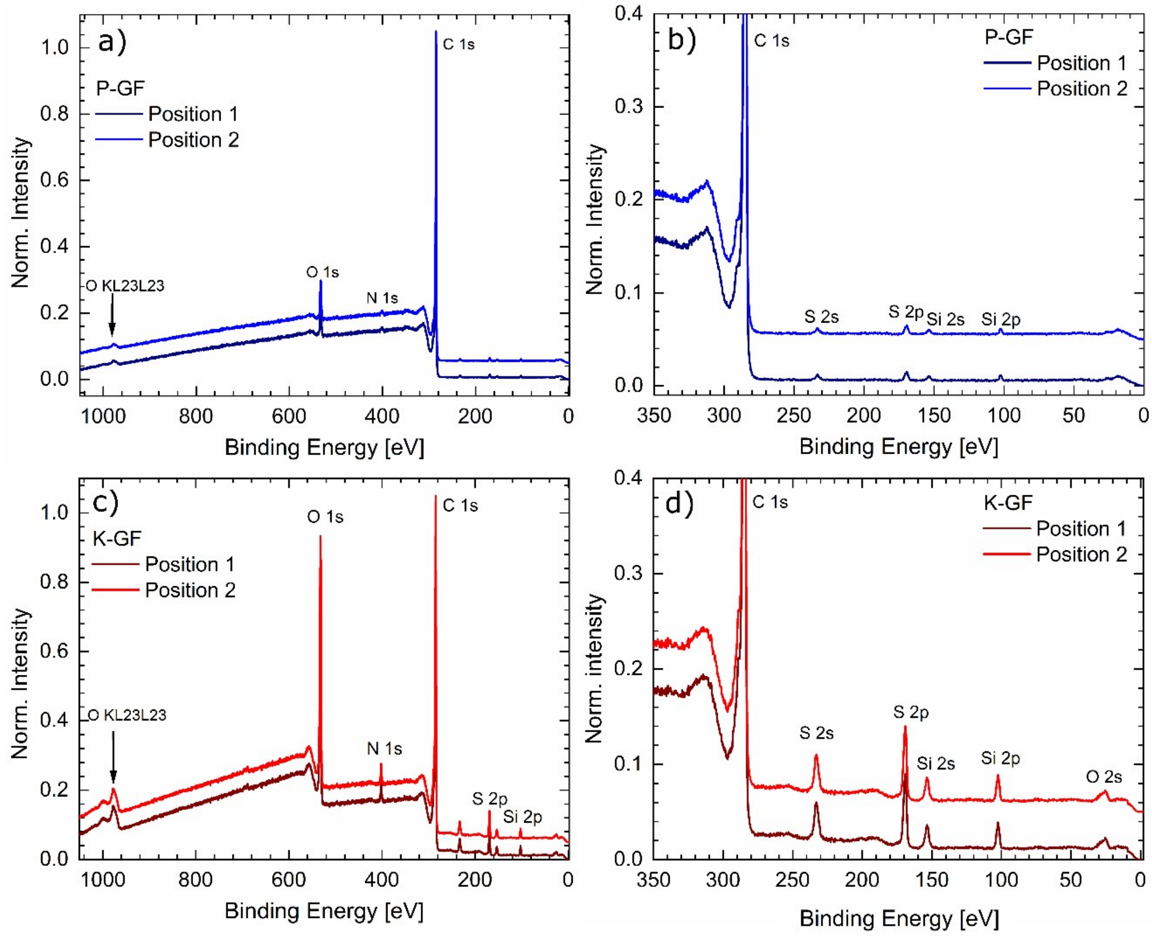

Figure S5: XPS spectra of the P-GF electrode survey (a) and semicore states (b) and K-GF electrode survey (c) and semicore states (d).

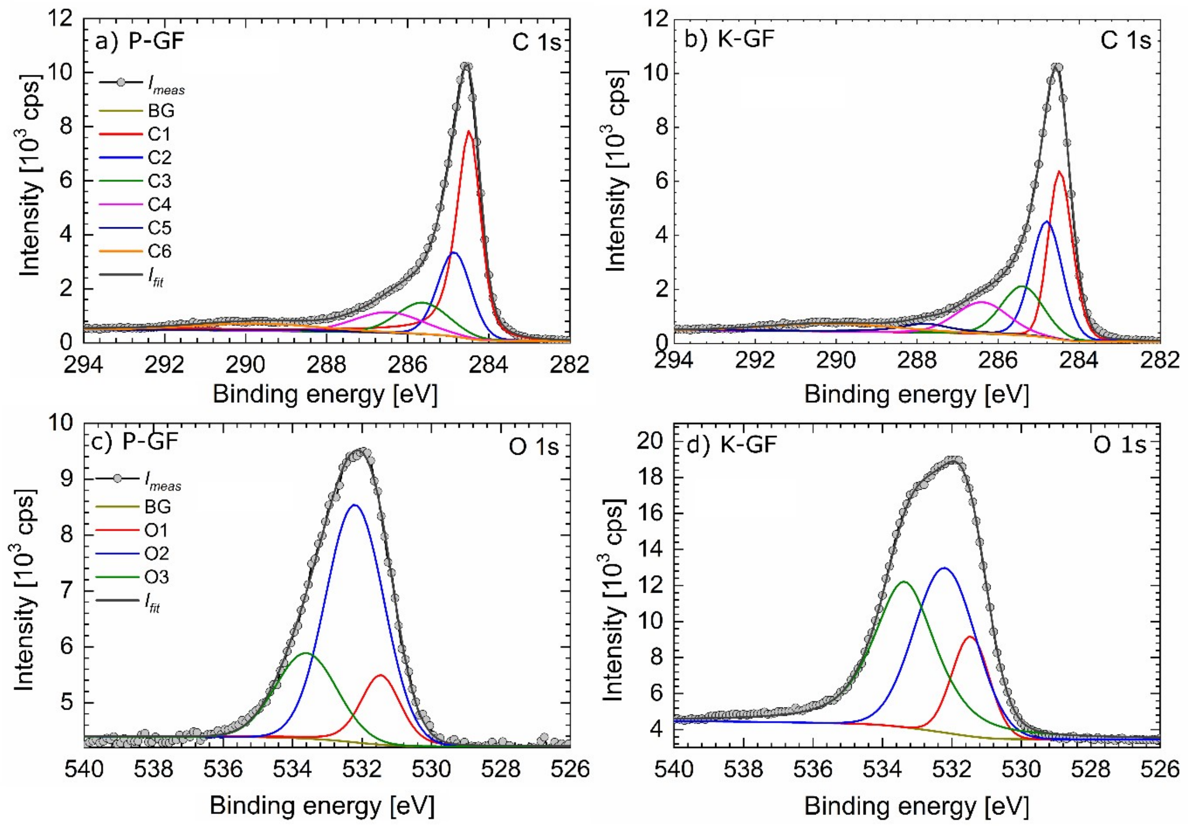

Figure S6: Peak fitting of C1s (a, b) and O1s (c, d) of the P-GF and K-GF samples. Special attention must be given to the y-axis scale on (c) and (d).

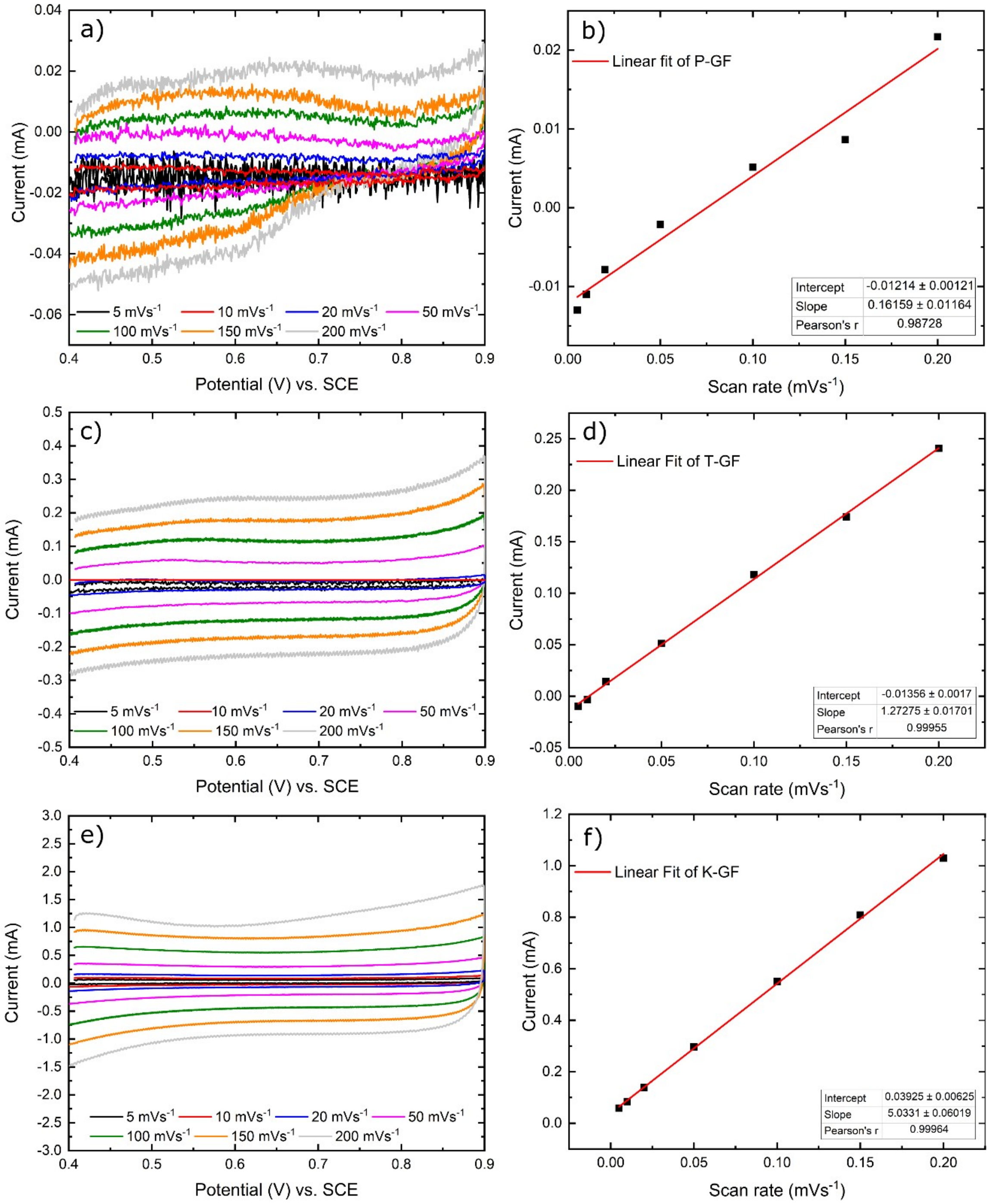

Figure S7: EDLC measurement of the P-GF, T-GF and P-GF electrodes. CV was performed in a potential range of 0.4 to 0.9 V vs. SCE with different scan rates (200, 150, 100, 50, 20, 10, and 5 mVs^{-1}) in 2 M H_2SO_4*. The peak currents of a) P-GF, c) T-GF and e) K-GF at 0.6 V were plotted against scan rates and fitted linearly in b), d) and f) respectively.*

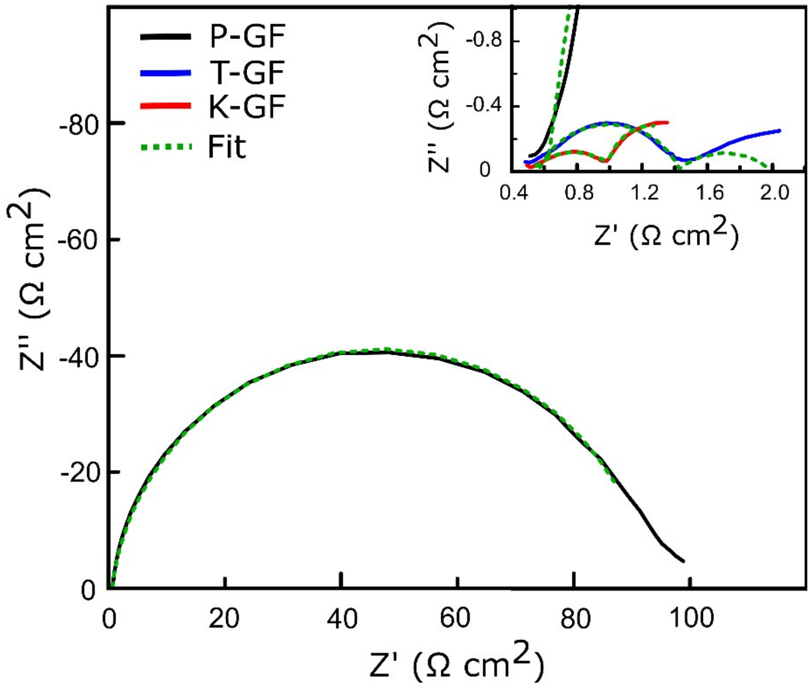

Figure S8: EIS curves of P-GF, T-GF and K-GF electrodes in the frequency range of 10^{-1} to 10^{4} Hz. Inset: Focused view of the T-GF and K-GF electrodes. Real and Imaginary ohmic values were multiplied by the active geometric cell electrode area (4 cm^2). Equivalent circuit fits are displayed as dashed green lines.

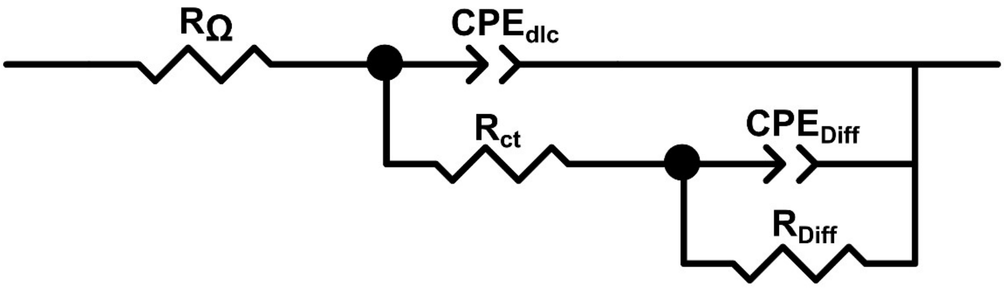

Figure S9: Equivalent circuit used to fit T-GF and K-GF EIS data of Figure S8. R_{Ω} corresponds to the ohmic resistance of the cell and is equal to the HFR. R_{ct} is the charge transfer resistance and R_{Diff} is the finite diffusion resistance. CPE_{dlc} and CPE_{Diff} correspond to the double layer capacitance of the electrode/electrolyte interface and the diffusion capacitance of the vanadium ions into the electrode structure, respectively.

Table S2: Obtained values from fitting Nyquist plots displayed in Figure S7 using the equivalent circuit shown in Figure S8.

Electrode	**R_{Ω} (Ω cm^2)**	**R_{ct} (Ω cm^2)**
P-GF	0.65	90.50
T-GF	0.56	0.88
K-GF	0.51	0.53