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Supplementary Material

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Multifunctional Graphene-Polymer Nanocomposite Sensors Formed by One Step in-situ Shear Exfoliation of Graphite

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1. Wireless Sensing Diagram

Batteryless, wireless strain sensor using resonant frequency modulation. A readout system with resistant and inductor (RL) component.

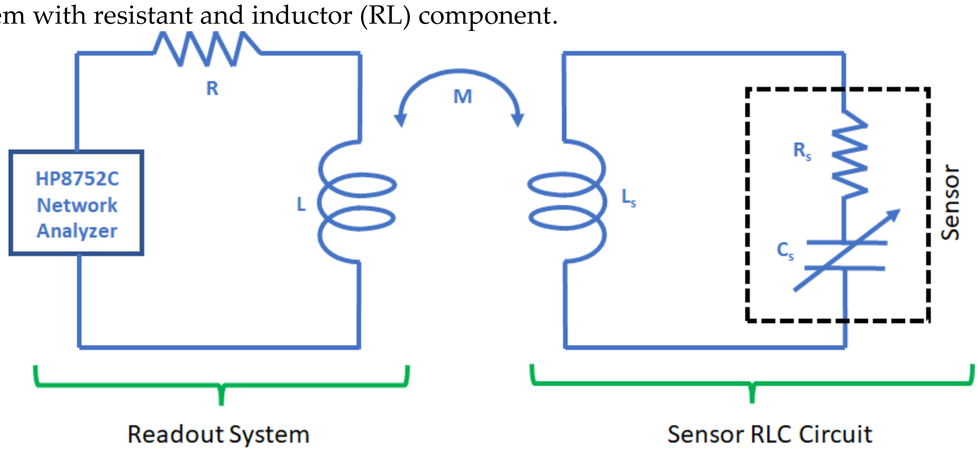

Figure S1: Schematic of a passive wireless sensor with a readout system.

2. Electrochemical Sensing

Electrochemical sensors, in particular, are a type of chemical sensor in which an electrode serves as a transducer in presence of an analyte. The Receptor, analyte, and transducer are the three main components of an electrochemical sensor. In most electrochemical sensors, electrodes play the role of transducers which convert the chemical reaction at the electrode surface to a measurable electrical signal. Among various electrochemical methods, Electrochemical Impedance Spectroscopy (EIS) is one of the used methods for rapid detection. This procedure identifies and calculates parameters using a model created using the frequency response of the investigated electrochemical system. In these studies, a frequency response analyzer connected to an electrochemical interface evaluates the system's current response as the frequency of an input sinusoidal signal is changed. In response to the Sinusoidal Voltage applied to the sample, a complex impedance vector is calculated with the resulting current using the given equation, $Z=R-jXc$.

R is the resistance, Xc is the capacitive reactance equal to $1/\omega C$ ($\omega=2\pi f$, f is the frequency of applied voltage and current), and the value of j is $\sqrt{1}$. EIS Results are frequently related to an electrical circuit, from where electrolyte resistance, ionic conductivity, the capacitance of the electrical double layer, and electron transfer resistance can be calculated.

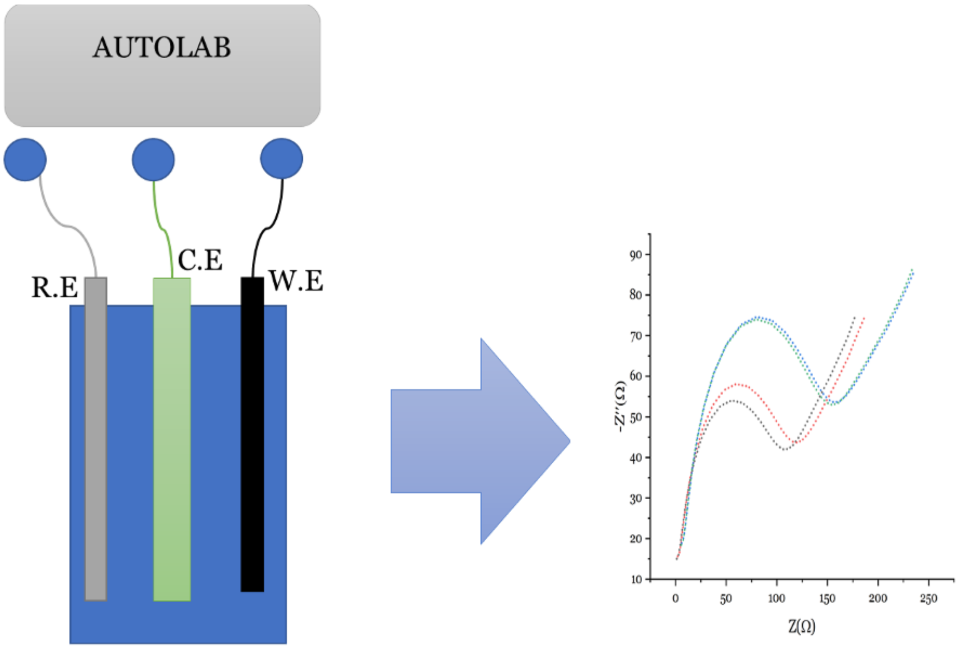

Figure S2. Experimental Setup for electrochemical sensing of dopamine with G-PSU and G-PVDF.

3. Thermal Property Results

The melting temperature of PVDF is 170 °C, and ranges between 166 – 169 °C for 5, 10, 20, and 30 wt. % GNFs in PVDF. The melting peak for 10, 20, and 30 wt. % GNFs in PVDF shows a double peak, which may indicate the formation of two types of crystals during the melt-mixing process, including surface and bulk crystallization of PVDF. The presence of pristine, new GNF surfaces created during exfoliation directly in the polymer, may give rise to surface crystallinity of PVDF on these GNF surfaces, as well as PVDF crystal formed within the bulk polymer. The heat of fusion is fairly constant for all concentrations and between the first and second heat, ranging between 30-33 J/g in the first heat and 31-33 J/g in the second heat. The heat of crystallization is also similar across all concentrations, ranging between 28-30 J/.

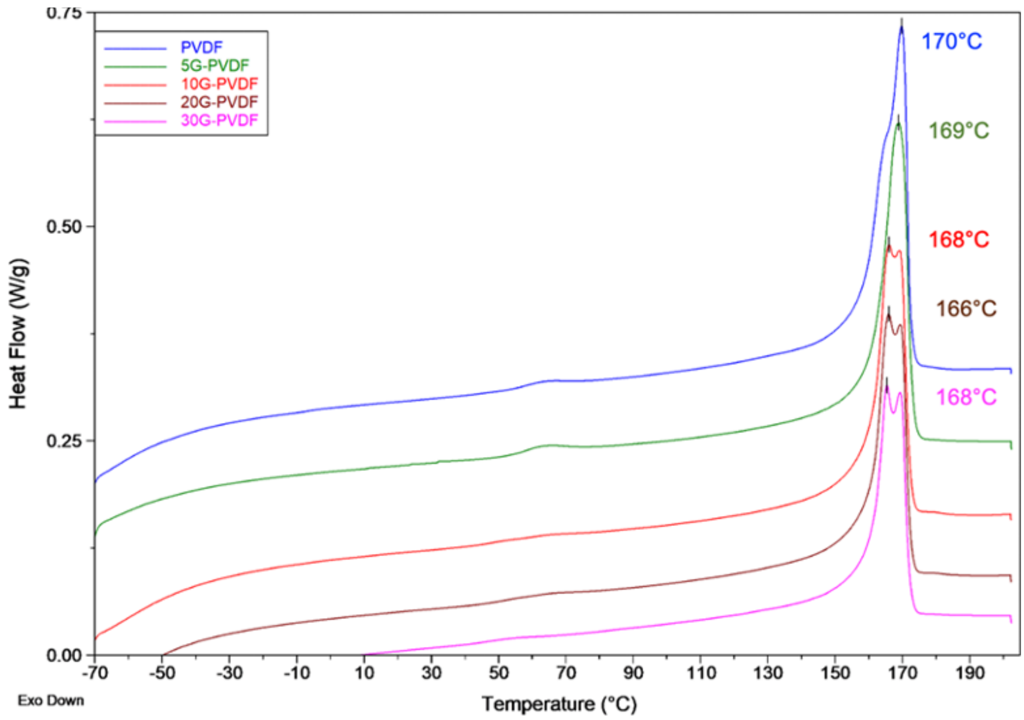

Figure S3: First heating curve.

Table S1. Thermal property results for G-PVDF obtained using a DSC.

	First Heat Heat			**Cooling**			**Second**		
% GNFs in PVDF	Tm 1 (°C)	ΔHf 1 (J/g)	Xc[a] (%)	Tc (°C)	Hc (J/g)	Xc[b] (%)	Tm[2] (°C)	ΔHf 2 (J/g)	Xc[c] (%)
0	170	31	29.6	142	30	28.6	168	33	31.2
5	169	31	29.1	150	28	26.8	169	32	30.0
10	168	30	28.9	150	28	27.1	169	32	30.6
20	166	32	30.9	150	32	30.1	169	31	29.8
30	168	33	31.1	150	29	27.3	169	32	30.1

4. Cyclic Loading Test

An Instron 5982 universal testing system with a 1 kN load cell and a Keithley 2450 SMU were used to load the specimen in a 3-point bend configuration. The sample was cyclically loaded and unloaded while the SMU was set to voltage bias at 10 V and a current limit of 1 A.

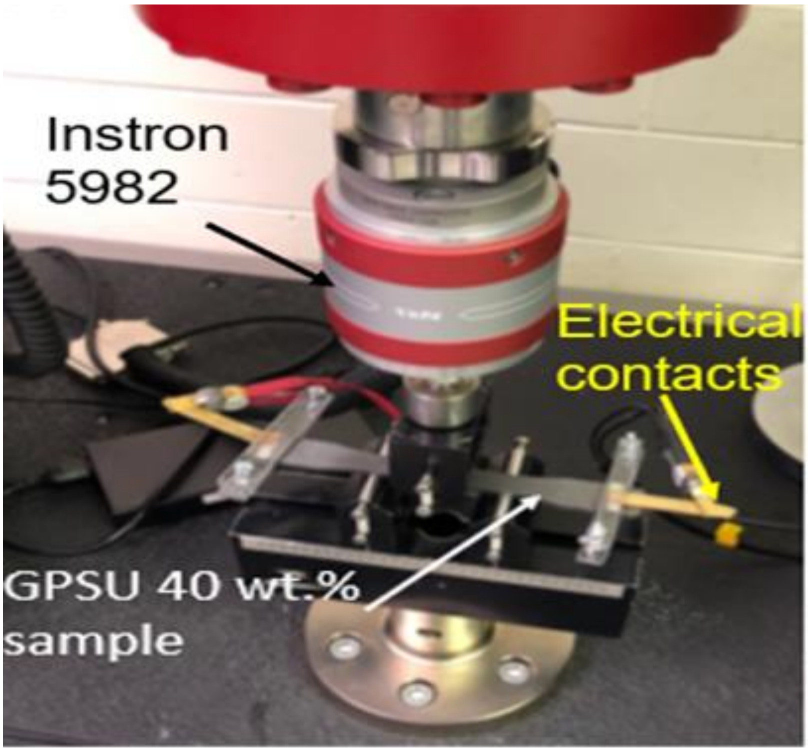

Figure S4. Experimental setup used for cyclic loading test.