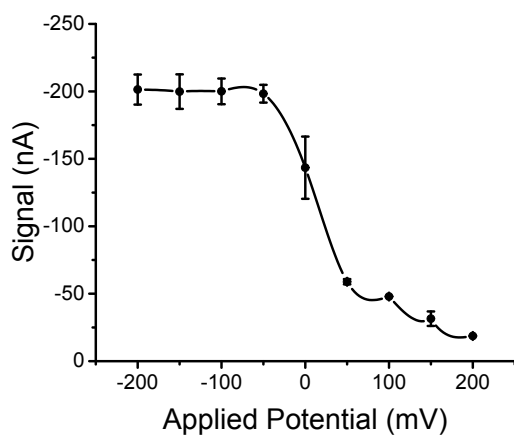
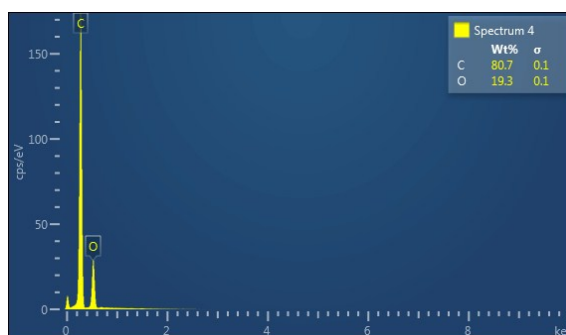
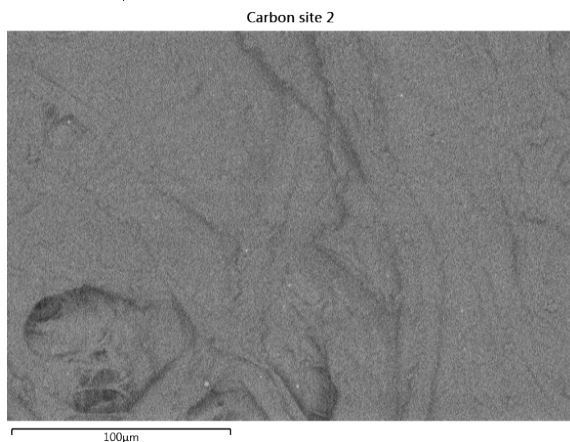
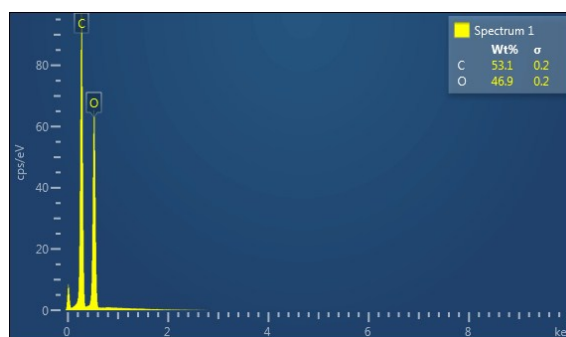
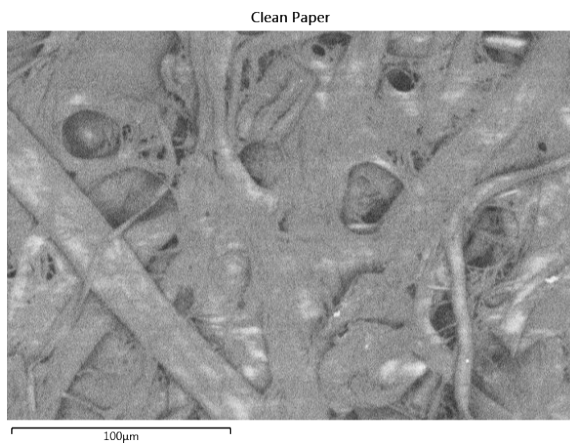


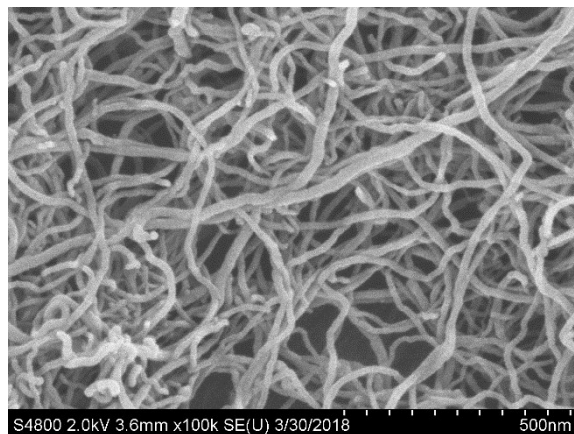
Supplementary Information for Carbon Tape as Convenient Electrode Material for Electrochemical Paper-Based Microfluidic Devices (ePADs)



S1: Hydrodynamic voltammogram for 0.01 mM phenol with phosphate buffer (pH 7.2) as the supporting electrolyte. A steady state reductive current is reached at -50 mV and was chosen as the optimal working potential.

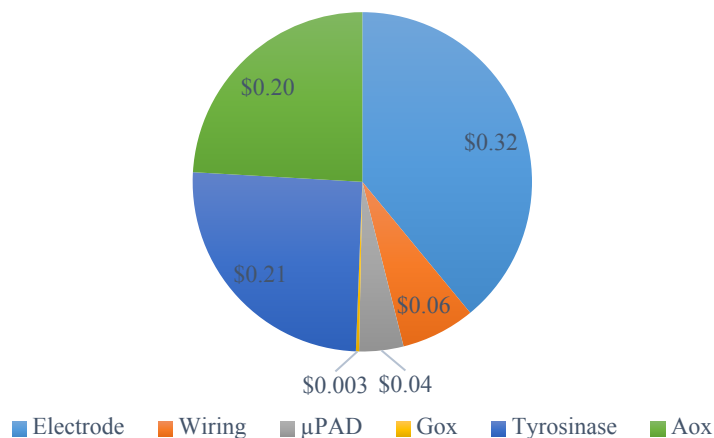


S2: SEM-EDS images obtained by the Electron Microscopy Laboratory at Clemson University. Plain chromatography paper (top) shows a distribution of carbon and oxygen as expected of cellulose however where CNTs have been placed (bottom) show a decreased area of oxygen and a higher intensity of carbon suggesting the successful integration of the CNTs into the fibrous structure of the cellulose.

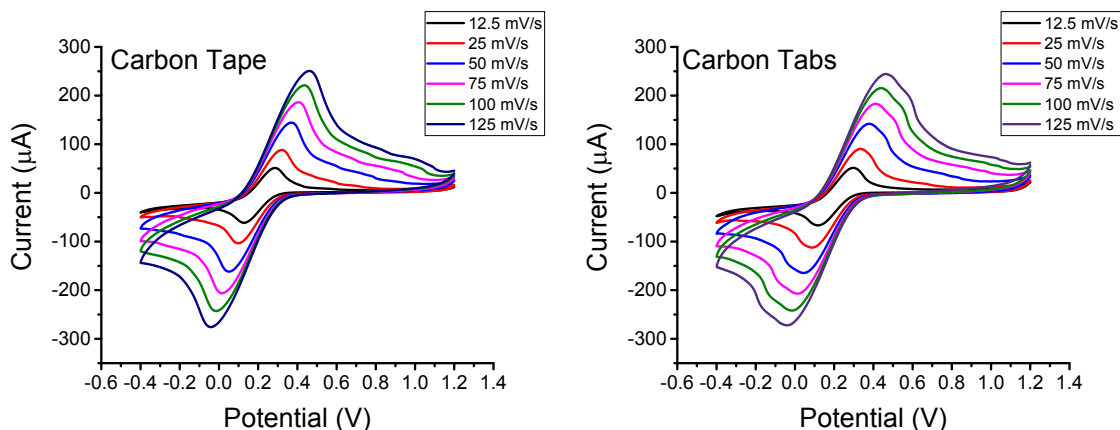


S3: SEM image of CNT modified paper substrate obtained at the Electron Microscopy Laboratory at Clemson University. The fibrous structure of the cellulose is retained.

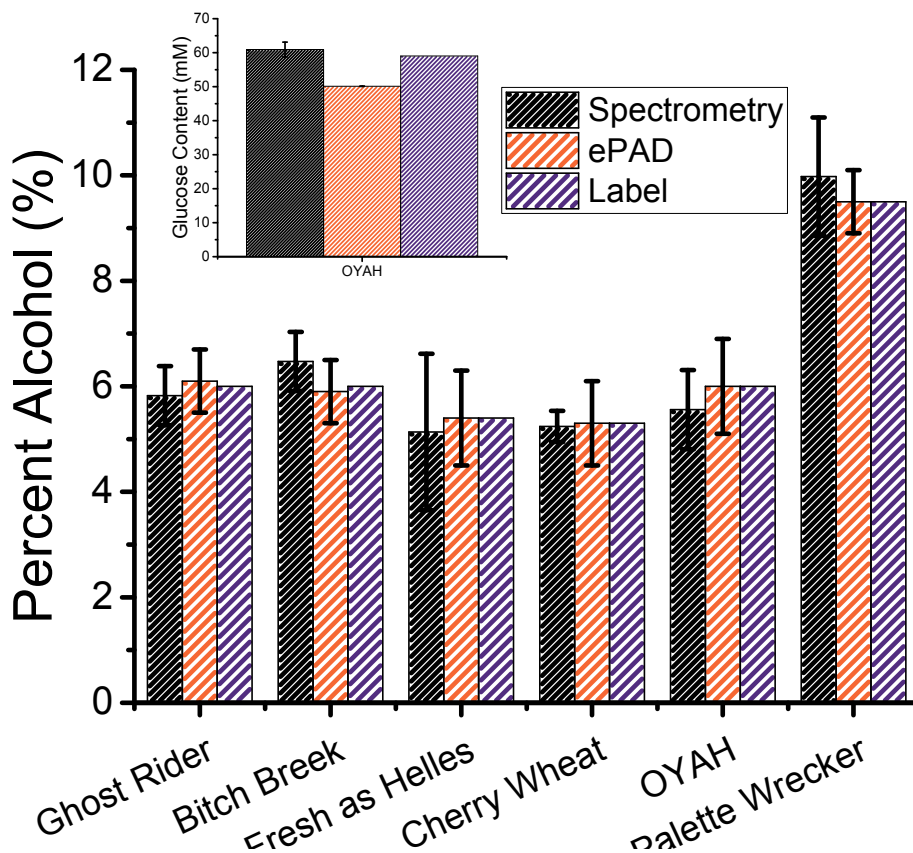
Cost of Prepared Device



S4: Cost analysis of one device. Electrode material was purchased at \$39.75 for 10 sheets. Each sheet yielded 144 electrodes total making the cost per electrode \$0.027 and 32 cents per device containing twelve electrodes. The electrode cost was the most expensive material highlighting the importance of the reduction of cost compared to commonly used inks. 65.5 ft of wiring cable was purchased for \$7.69 and 0.5 ft was used per device yielding a total cost of 6 cents. 3MM chromatography paper was purchased for \$56.72 for 100 sheets and each sheet yielded 16 devices making the total cost 4 cents. 14.4 g of glucose oxidase (Gox) was purchased for \$762 and 5 uL of a 1 mg/mL solution was used per device making the cost less than one cent (\$0.003). Tyrosinase from mushroom was purchased at \$98.50 for 25 mg, and since 5 uL of a 1 mg/mL solution was used, therefore the total cost for tyrosinase came to 21 cents. In a similar manner, alcohol oxidase was purchased at \$263 for 60 mg making the total cost 20 cents for alcohol oxidase. When added together the total cost for one device is \$0.83

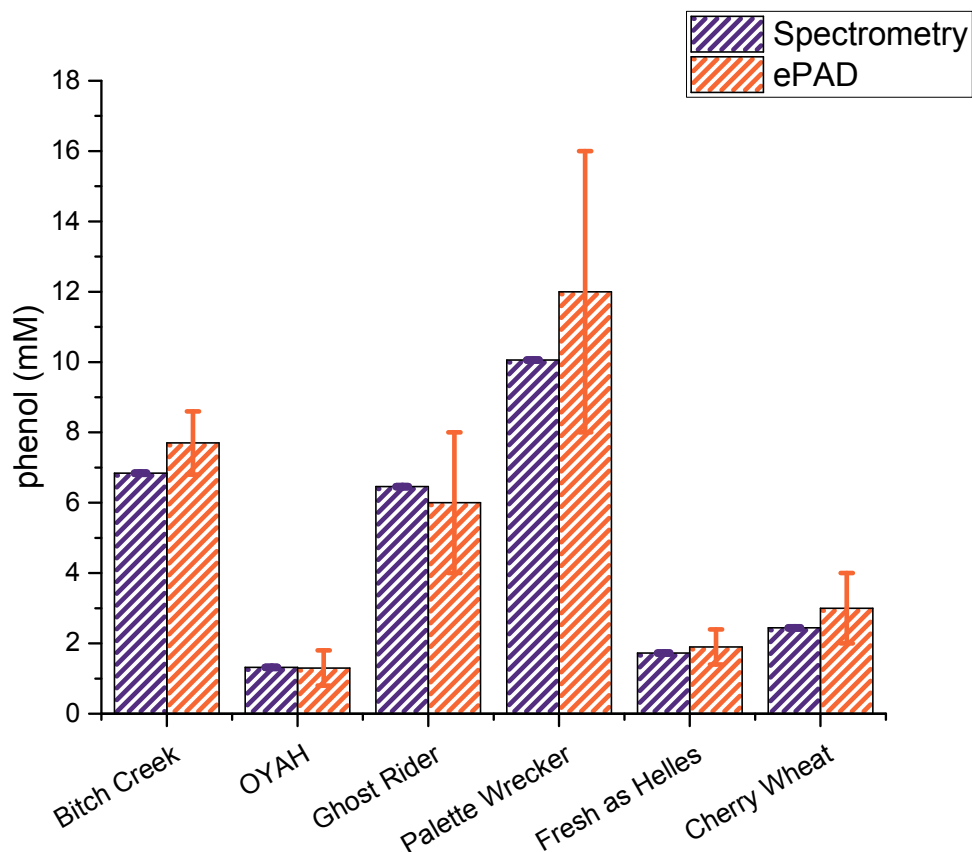


S5: Cyclic voltammograms obtained with 0.1 M phosphate buffer system as the supporting electrolyte and 0.1 M $K_3Fe(CN)_6$ as the redox couple. While the two materials gave similar peak currents and peak potential differences, the peak shape is more defined for the carbon tape material.



S6: Validation of the obtained ePAD results for sugar content and alcohol content. Glucose and ethanol content was validated via a PerOXquant colorimetric assay for hydrogen peroxide coupled to the appropriate enzyme (glucose oxidase or alcohol oxidase). 1 mL of beer sample was mixed with 1 mg of enzyme, (to achieve the same activity as the ePAD) and mixed with the appropriate amount of

PerOXquant working reagent. The absorbance of the samples was taken 20 minutes later at 560 nm as suggested by the user manual for the kit. The absorbance of the samples were compared to a calibration curve obtained for peroxide. From the redox equation for each enzyme one mole of reagent (glucose or ethanol) yields one mole of product (hydrogen peroxide), therefore there is a direct relationship between the concentration of hydrogen peroxide detected and the original concentration of glucose and ethanol. These results were also compared to the reported alcohol content on the label of the beer sample. From the graph the ePAD data matches both the spectrophotometry and reported values with 92% accuracy or greater for alcohol and 85% accuracy for sugar content.



S7: Validation of phenol concentration. Phenol can be visualized when mixed with chitosan and tyrosinase that yields a brownish-red color.¹ 10 mM phenol was mixed with 0.125% (w/v) chitosan and 1500 units/mL tyrosinase to yield the brown color. The absorbance was scanned from 300 nm to 700 nm and a broad peak absorbance was found at 415 nm. Several concentrations of phenol were made in the same manner and their absorbance were found at 415 nm to generate a calibration curve. Lastly, 1:10 diluted beer and cider samples were mixed with the chitosan and tyrosinase, then the absorbance was recorded at 415 nm. From the calibration curve, it was possible to calculate the concentration of phenol in the beer and cider samples, which were compared to the concentration found by the prepared device. As it can be seen, there is overlap between the two methods when the error is taken into account. This overlap suggests that there is no difference between the methods and that the phenol concentration results recorded by the prepared device are accurate.

1. R. Alkasir, M. Ornatska and S. Andreescu, *Analytical Chemistry*, 2012, **84**, 9729-9737.

