Electronic Supplementary Information

Simple cost-effective paper-based electrochemical device for detection of adulterated sibutramine in slimming products

Kitima Sirivibulkovit\textsuperscript{1,2}, Prapin Wilairat\textsuperscript{1,3}, Duangjai Nacapricha\textsuperscript{1,2}, Sineewanlaya Wichit\textsuperscript{4}, Phoonthawee Saetear\textsuperscript{1,2*}

\textsuperscript{1}Flow Innovation-Research for Science and Technology Laboratories (Firstlabs)

\textsuperscript{2}Department of Chemistry and Center of Excellence for Innovation in Chemistry, Faculty of Science, Mahidol University, Rama 6 Road, Ratchatewi, Bangkok, 10400, Thailand.

\textsuperscript{3}Analytical Sciences and National Doping Test Institute, Mahidol University, Rama 6 Road, Ratchatewi, Bangkok, 10400 Thailand

\textsuperscript{4}Department of Clinical Microbiology and Applied Technology, Faculty of Medical Technology, Mahidol University, Nakhon Pathom, 73170, Thailand

*Corresponding author: Tel +66 2201 5122; Fax +66 2201 5127

Email: phoonthawee.sae@mahidol.edu

Electronic Supplementary Information

Appendix A Evaluation of reproducibility of the production of the ePADs

Fig. S1. Pattern of electrodes of single sheet. One production process provides 16 ePAD devices.

Fig. S2. Scatter plots of the measured oxidation ($i_{pa}$) and reduction ($i_{pc}$) peaks of 48 ePADs from three production processes. The solid horizontal lines are the mean of the oxidation ($i_{pa}$) and reduction ($i_{pc}$) peak currents and the dashed horizontal lines are mean ± 3SD of the 48 devices.
Fig. S3. Cyclic voltammograms of 6.0 mM K$_3$Fe(CN)$_6$ (solid lines) in 0.1 M KCl supporting electrolyte (dotted line) obtained from the ePAD device in the test of repeat use of the sensor: 30 scan-cycles of a single sensor.

Table S1. Mean of the peak currents and peak current ratios ($i_{pa}/i_{pc}$) of 16 ePADs selected from 16 screen-printed sheets.

Appendix B  
**Electrochemical cells used in this work**

Table S2. Images and specifications of the four types of electrochemical cells used for the investigation of the voltammetric behavior of sibutramine.

Appendix C  
**Qualitative data for samples spiked with standard sibutramine**

Fig. S4. Qualitative data of (a-h) square-wave voltammograms and (i-p) UV-vis spectra of eight samples (black lines) before and after spiking with standard sibutramine (red lines) and the background signals of the buffer solution (dotted lines).
Appendix A

Evaluation of reproducibility of the production of the ePADs

One production process provides 16 ePADs. The pattern of the electrodes on one sheet is shown in Fig. S1.

![Pattern of electrodes of single sheet](image)

**Fig. S1.** Pattern of electrodes of single sheet. One production process provides 16 ePAD devices.

Each ePAD was tested by using the device to measure the cyclic voltammograms of a 6.0 mM K$_3$Fe(CN)$_6$ solution in 0.1 M KCl, as supporting electrolyte. The peak currents of anodic ($i_{pa}$) and cathodic ($i_{pc}$) scans were then determined. Fig. S2 is a scatter plot of the measured ($i_{pa}$) and ($i_{pc}$) of the 48 ePADs, divided into three sections, with control bands defined by the mean ± 3 SD of the 48 ePAD devices. It is observed that all the signals are within the control band, indicating that the production of ePAD by screen-printing method is reproducible.
Fig. S2. Scatter plots of the measured oxidation ($i_{pa}$) and reduction ($i_{pc}$) peaks of 48 ePADs from three production processes. The solid horizontal lines are the mean of the oxidation ($i_{pa}$) and reduction ($i_{pc}$) peak currents and the dashed horizontal lines are mean ± 3SD of the 48 devices.

Then, we calculated the peak current ratio ($i_{pa}/i_{pc}$) obtained from each screen-printed sheet (16 ePAD devices). Table S2 shows the mean of peak current ratio from 16 devices in each production of ePAD is close to 1, indicating our ePAD device are the same as conventional electrochemical cell for measurement of the reversible redox reaction of K$_3$Fe(CN)$_6$.

Fig. S3. Cyclic voltammograms of 6.0 mM K$_3$Fe(CN)$_6$ (solid lines) in 0.1 M KCl supporting electrolyte (dotted line) obtained from the ePAD device in the test of repeat use of the sensor: 30 scan-cycles of a single sensor.
Table S1. Mean of the peak currents and peak current ratios ($i_{pa}/i_{pc}$) of 16 ePADS selected from 16 screen-printed sheets

<table>
<thead>
<tr>
<th>Sheet</th>
<th>$i_{pa}$ (µA)</th>
<th>$i_{pc}$ (µA)</th>
<th>Peak current ratio ($i_{pa}/i_{pc}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>78 ± 4</td>
<td>69 ± 3</td>
<td>1.14 ± 0.08</td>
</tr>
<tr>
<td>2</td>
<td>72 ± 4</td>
<td>65 ± 4</td>
<td>1.12 ± 0.09</td>
</tr>
<tr>
<td>3</td>
<td>75 ± 4</td>
<td>68 ± 3</td>
<td>1.11 ± 0.08</td>
</tr>
</tbody>
</table>
Appendix B

Electrochemical cells used in this work

**Table S2.** Images and specifications of the four types of electrochemical cells used for the investigation of the voltammetric behavior of sibutramine

<table>
<thead>
<tr>
<th>Type</th>
<th>Conventional</th>
<th>DropSens&lt;sup&gt;TM&lt;/sup&gt;</th>
<th>Zensor&lt;sup&gt;TM&lt;/sup&gt;</th>
<th>ePAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image of electrochemical cell</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Specification</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of material:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working electrode (WE)</td>
<td>Glassy carbon</td>
<td>Carbon</td>
<td>Carbon</td>
<td>Carbon</td>
</tr>
<tr>
<td>Counter electrode (CE)</td>
<td>Pt wire</td>
<td>Carbon</td>
<td>Carbon</td>
<td>Carbon</td>
</tr>
<tr>
<td>Reference electrode (RE)</td>
<td>Ag/AgCl</td>
<td>Ag/AgCl</td>
<td>Ag/AgCl</td>
<td>Ag/AgCl</td>
</tr>
<tr>
<td>Diameter of WE (mm)</td>
<td>2.5</td>
<td>4</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>Volume of sample (µL)</td>
<td>~20,000</td>
<td>40</td>
<td>40</td>
<td>60</td>
</tr>
</tbody>
</table>
Appendix C

Qualitative data for samples spiked with standard sibutramine

**Fig. S4** Qualitative data of (a-h) square-wave voltammograms and (i-p) UV-vis spectra of eight samples (black lines) before and after spiking with standard sibutramine (red lines) and the background signals of the buffer solution (dotted lines).