Conducting 3D-carbon scaffolds induce spontaneous differentiation of human neural stem cells and measure neurotransmitter release in real-time

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Tailoring the structure and the properties of pyrolysed carbon electrodes

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Here we present a study with pyrolysed carbon derived from the photoresist SU-8, polystyrene (PS) and polystyrene-blockpolydimethylsiloxane (PS-PDMS) copolymers (Fig. 1) to evaluate them as electrode material. XPS analysis showed that pyrolysed PS-PDMS contains an atomic percentage of 29% silicon. The silicon content may be a limiting factor for obtaining high-conductive structures due to lower carbon content (19%) compared to PS (96%) and SU-8 (98%), but at the same time the silicon is functioning as support for the 3D structure (fig. 1B). Raman spectra of pyrolysed carbon derived from SU-8 photoresist, revealed the presence of the so called D and G peaks (Fig. 1C), indicating that both amorphous and graphitic regions are contributing. The peak intensity ratio of the D and G peaks varies with the microstructural disorder of the carbon matrix\(^1\). From the Raman spectra, the calculated \(I_D/I_G\) is higher for pyrolysed films of PS-PDMS (\(I_D/I_G = 1.1\)) compared to SU-8 and PS (\(I_D/I_G = 1\)), indicating higher microstructural disorder of pyrolysed PS-PDMS. Additionally, the standard rate constant for electron transfer (\(k^0\)) was determined from the experimental \(\Delta E_p\) with the method of Nicholson\(^2\) (table 1). The slower electron transfer kinetics of PS-PDMS compared to PS and SU-8 films may be related to its lower carbon content, as well as to its higher microstructural disorder.

![Figure 1. SEM images of pyrolysed PS (A) and PS-PDMS (B). C) Raman spectra of pyrolysed films derived from PS-PDMS, PS, and SU-8, respectively.](image)

**Table 1.** \(k^0\) values calculated from the experimental \(\Delta E_p\) of the CVs obtained in 1mM Ru(NH\(_3\))\(_6^{3+/2+}\), scan rate 10 mV s\(^{-1}\).

<table>
<thead>
<tr>
<th>Electrode material</th>
<th>(\Delta E_p) (mV)</th>
<th>(k^0) (cm s(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS-PDMS</td>
<td>109</td>
<td>8,0E-02</td>
</tr>
<tr>
<td>PS</td>
<td>78</td>
<td>3,3E-01</td>
</tr>
<tr>
<td>SU-8</td>
<td>92</td>
<td>1,2E-01</td>
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