Electroactive Polypyrrole Nanoparticles for Different Functions

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Here, we report synthesis of poly(vinyl alcohol) (PVA)-based polypyrrole (PPy) nanoparticles (NPs) with high electroactivity. The polymerization process, initiated by $FeCl_3$, is known for obtaining the PPy with appreciable conductivity [1]. Polymer growth was terminated with an excess of PVA chains, surrounding the forming polymer structures with PVA chains by limiting the interactions between pyrrole cation radicals. Hence, the polymer formation was terminated on the stage of NPs, not on a bulk polymer (Figure 1a).

Additionally, we synthesized PVA-stabilized PPy NPs enriched with a mer derivatized with carboxyl groups. Copolymerization with a carboxyl derivative was confirmed by XPS. DLS measurement confirmed that copolymerization with a carboxyl derivative of pyrrole introduced charge and electrostatic properties on the NPs, which resulted in the increase of zeta potential. SEM imaging confirmed the synthesis of spherical (Fig. 1a), uniformly small and well-dispersed NPs of the size below 50 nm (Figure 1b).

These PPy and PPy-PyCOOH NPs were extensively characterized by CV. PPy NPs showed high electroactivity in comparison to PPy-PyCOOH NPs. The redox activity of $K_4Fe(CN)_6/K_3Fe(CN)_6$ measured over PPyNP modified shows current enhancement (Figure 1c). However, such enhancement was only visible when potential was scanned in the potential window where PPy electroactivity was observed.

Electroactivity of PPy-PyCOOH NPs was slightly lower than PPy NPs. Presence of COOH group on NPs allowed further modification of the NPs with ferrocene moiety. NPs with functionally tuned shell surfaces can be applied in applications, such as electrocatalysis, and sensing.

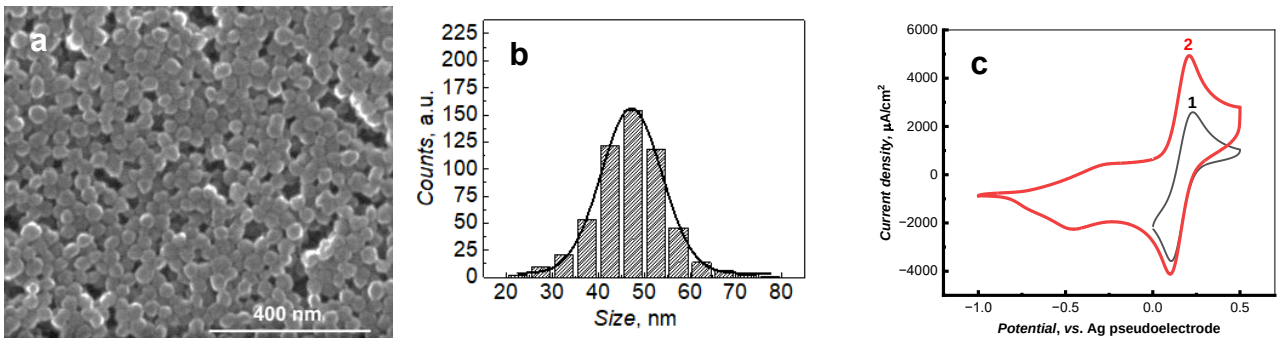

Figure 1. (a) SEM image of PPy NPs and (b) statistical size distribution. (c) CV measured on PPy NP modified GC in the presence of 10 mM $K_4Fe(CN)_6/K_3Fe(CN)_6$ in 100 mM phosphate buffer containing NaCl and KCl.

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Reference
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[2] A. Kisiel, D. Korol, A. Michalska, Krzysztof Maksymiuk, Polypyrrole nanoparticles of high electroactivity. Simple synthesis methods and studies on electrochemical properties, Electrochim. Acta 390 (2021) 138787.