Oxygen reduction reaction on Pt-nanowires synthesized in a superfluid helium

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Net structures formed by ultrathin (3–4 nm in diameter) long platinum nanowires (Fig. 1) obtained via the method of laser ablation from a platinum target in a superfluid helium at T < 1.5 K and deposited on the surface of a glassy carbon (GC) electrode were demonstrated to possess a high specific catalytic activity towards the oxygen reduction reaction (ORR) along with an outstanding long-term stability.

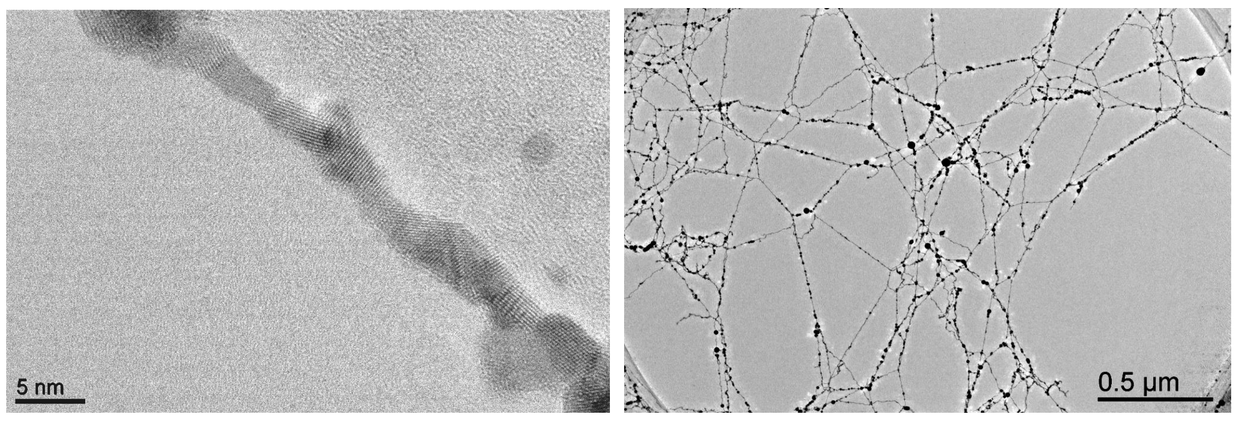

Fig. 1. *TEM images of Pt-nanowires at different scales.*

Fig. 2 demonstrates voltammograms measured in an air-saturated solution of 0.1M KOH for the composite electrode (Pt-GC) and a commercial Pt/Vulcan XC-72 catalyst, 40 wt. % Pt (Pt/C) at ν = 10 mV/s and ω = 2000 rpm. The curve obtained on the Pt-GC electrode is close in shape to that of Pt/C catalyst loaded onto the GC electrode, although the limiting diffusion current is somewhat lower and formally corresponds to the electron transfer number of ca. 3. At the same time, the dependencies of the ORR current density at –600 mV on ω plotted in the Koutecký-Levich coordinates (inset in Fig. 2) demonstrate close slopes corresponding to the electron transfer number of ca. 4.

The difference between the corresponding ORR limiting currents and overpotential values on the GC completely covered with Pt/C and Pt-GC electrode is apparently due to the size effect arising from the ratio of the diffusion layer thickness and the average distance between the ORR active centers, which was ca. 15 μm. Therefore, the average distance between the ORR active centers, which are nanowires, is somewhat larger than the thickness of the diffusion layer, and for this reason, the ORR current on this electrode is less than that on Pt/C.

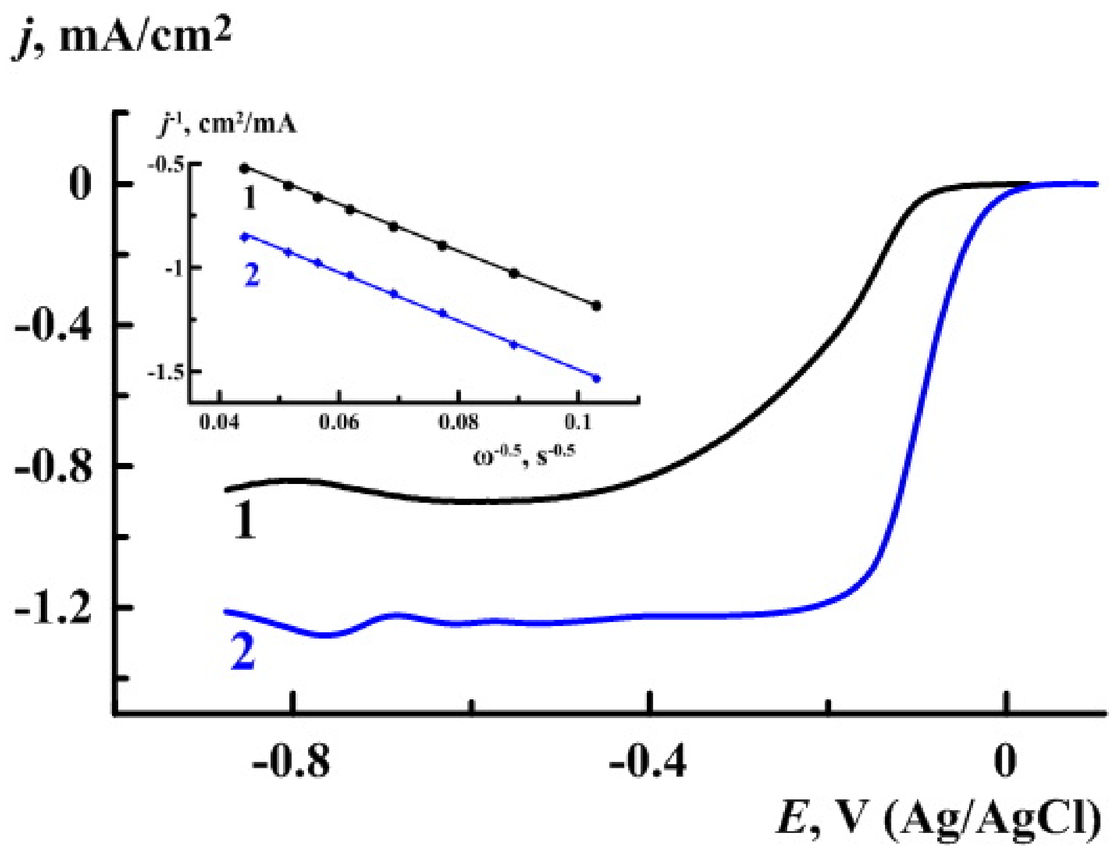

Fig. 2. *Linear sweep voltammetry in an air-saturated solution of 0.1M KOH for the Pt-GC (1) and Pt/C electrode (2); ω = 2000 rpm, ν = 10 mV/s. The inset shows relevant Koutecký-Levich plots at –600 mV.*

Durability tests have demonstrated a relatively high stability of the limiting diffusion current and the shape of the voltammograms for the Pt-GC electrode, which may be due to the difficulty of both the deallocation of extended objects and their agglomeration on the surface of GC.

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