

Supplementary materials

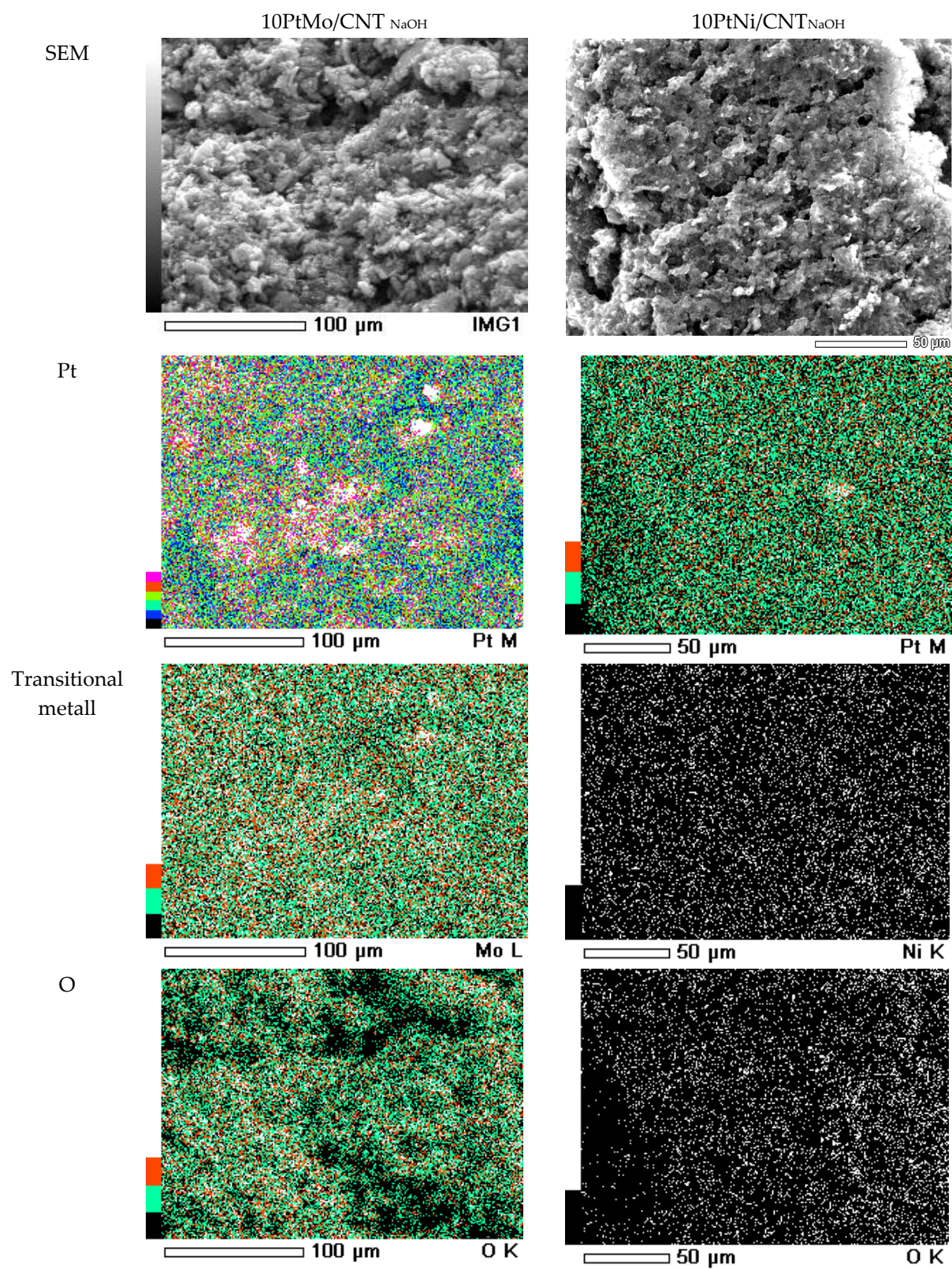


Figure S1. SEM image and elemental composition (EDX) of synthesized catalysts

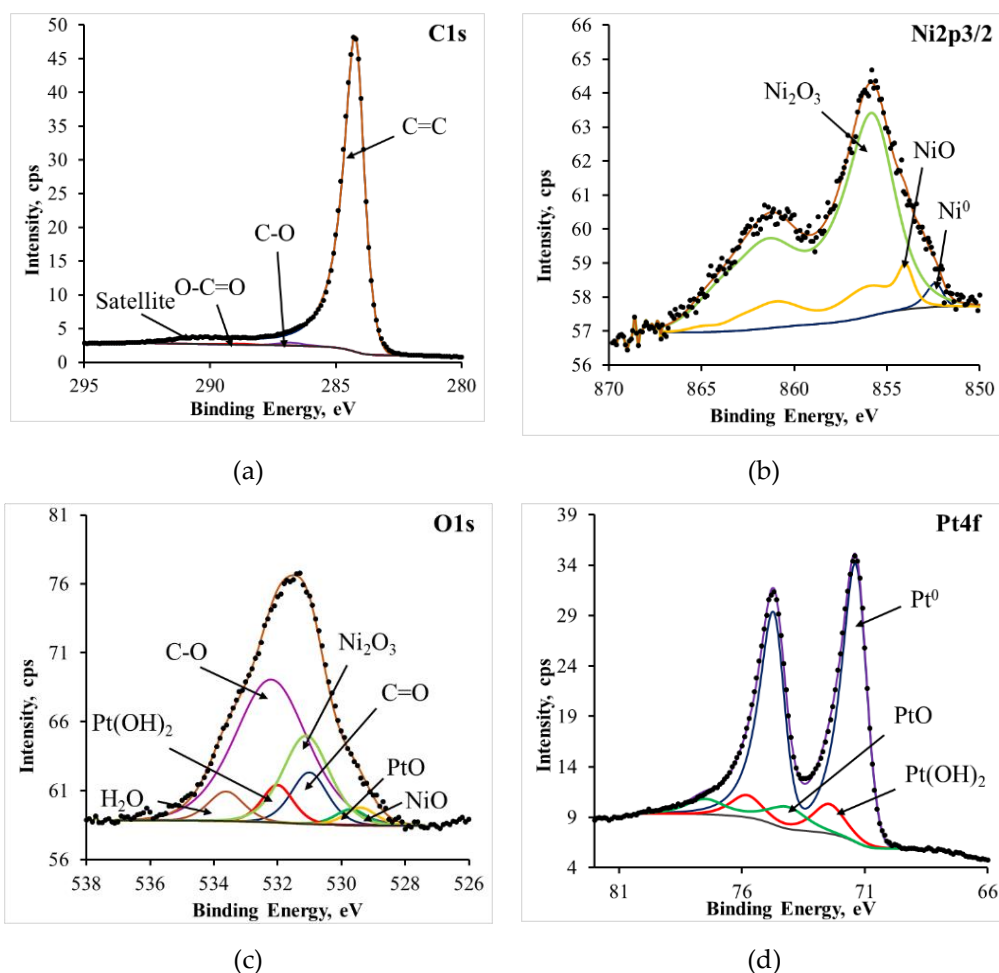


Figure S2. C1s (a), Ni2p3/2 (b), O1s (c), and Pt4f (d) X-ray spectra recorded on 10PtNi/CNT_{NaOH}

Detailed discussion of XPS.

The spectra of C1s electrons can be adjusted depending on the sample by three or four states. The asymmetric peak with a maximum at 284.2 eV with a pronounced satellite at 290 eV can be attributed to sp³-hybridized carbon, denoted C=C in the Figure S2 a, with a small fraction of sp²-hybridized carbon at the position of 285.0 eV, the peak of which is noticeable in original sample 10Pt/CNT_{NaOH}. The other two peaks can be attributed to oxygen-containing states of carbon such as C-O and C(O)O with maxima at 286.8 and 288.8 eV, respectively.

According to XPS studies, Figure S2 d, platinum is in three states: the most intense and a doublet with the position of the Pt4f7/2 peak at 71.4 eV, which can be attributed to Pt⁰; Pt(OH)₂ with a maximum of 72.4 eV and PtO at 74.2 eV.

On the oxygen spectrum of the original sample, 5 states of the element are observed, two of which refer to the carbon-bonded C=O and C-O atoms with positions 530.8 and 531.9 eV, respectively, the peak related to H₂O (533.4 eV), and also two states of PtO and Pt(OH)₂ with maxima at 529.8 and 532 eV, respectively. When Mo or Ni is added to 10Pt/CNT_{NaOH}, additional peaks appear, so in the first case at 530.6 eV, and in the second case at 529.5 and 531.1 eV. In the case of 10PtMo/CNT_{NaOH}, the presence of MoO₃ can be assumed, which is confirmed by the spectrum of molybdenum Mo3d, in which the Mo3d5/2 peak of the Mo3d doublet is located at 232.8 eV. On the 10PtNi/CNT_{NaOH} sample, the states of oxygen atoms can be additionally attributed to NiO (529.5 eV) and Ni₂O₃ (531.1 eV). In turn, three states of the element can be distinguished in the spectrum of Ni2p3/2 electrons: a low-intensity Ni⁰ peak with a maximum of 852.4 eV; a curve including satellites, NiO (854.4 eV) and also a complex curve at 856 eV, which can be attributed to Ni₂O₃.

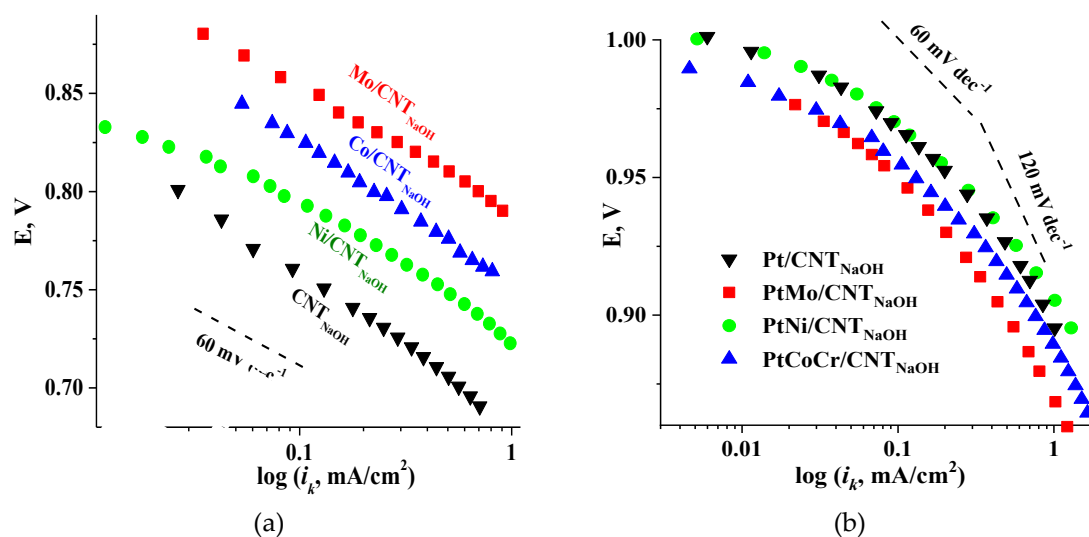


Figure S3. Tafel plots for a – transition metal catalysts, b – Pt-containing catalysts

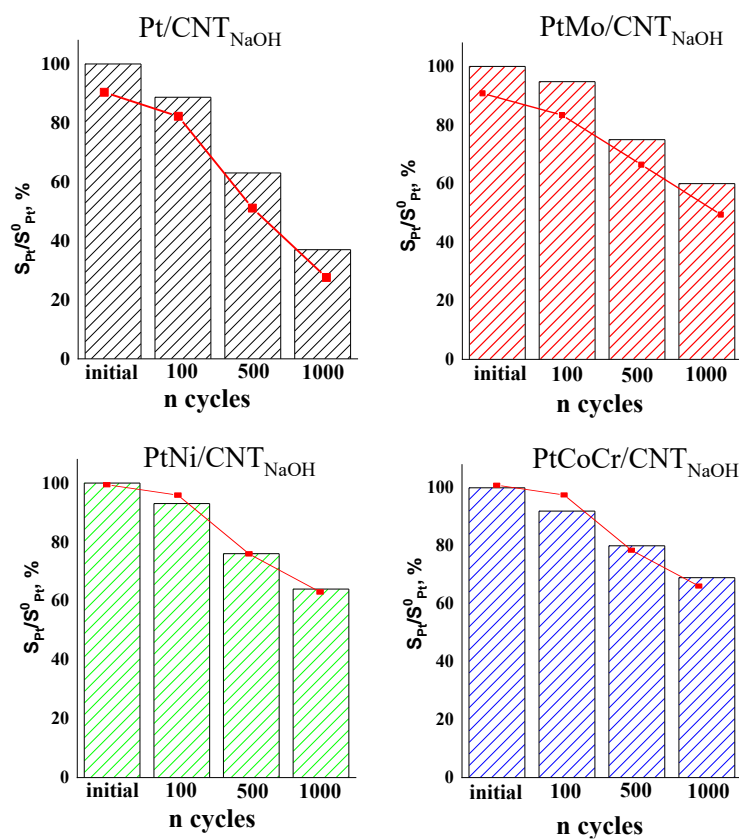


Figure S4. Diagrams of changes in the relative size of the surface of platinum during accelerated corrosion testing. 0.1M KOH, 50 mV/s, 100 $\mu\text{g/cm}^2$.