Iron single atom catalysts (Fe SACs) are the best-known nonprecious metal (NPM) catalysts for the oxygen reduction reaction (ORR) of polymer electrolyte membrane fuel cells (PEMFCs), but their practical application has been constrained by the low Fe SACs loading (<2 wt%). Here, a one-pot pyrolysis method is reported for the synthesis of iron single atoms on graphene (FeSA-G) with a high Fe SAC loading of ≈7.7 ± 1.3 wt%. The as-synthesized FeSA-G shows an onset potential of 0.950 V and a half-wave potential of 0.804 V in acid electrolyte for the ORR, similar to that of Pt/C catalysts but with a much higher stability and higher phosphate anion tolerance. High temperature SiO₂ nanoparticle-doped phosphoric acid/polybenzimidazole (PA/PBI/SiO₂) composite membrane cells utilizing a FeSA-G cathode with Fe SAC loading of 0.3 mg cm⁻² delivers a peak power density of 325 mW cm⁻² at 230 °C, better than 313 mW cm⁻² obtained on the cell with a Pt/C cathode at a Pt loading of 1 mg cm⁻². The cell with FeSA-G cathode exhibits superior stability at 230 °C, as compared to that with Pt/C cathode. Our results provide a new approach to developing practical NPM catalysts to replace Pt-based catalysts for fuel cells.