# Supplementary information
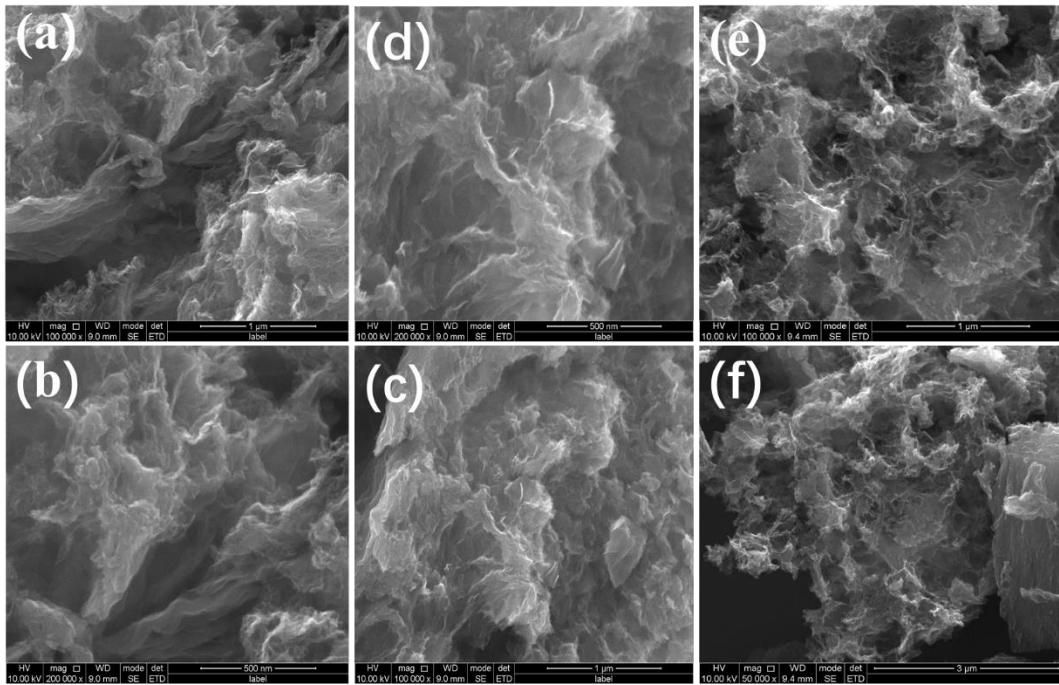


Fig.S1 SEM images of $CNP_{50}$-ns(a, b),$CNP_{200}$-ns(c, d),$CNP_{300}$-ns(e, f)
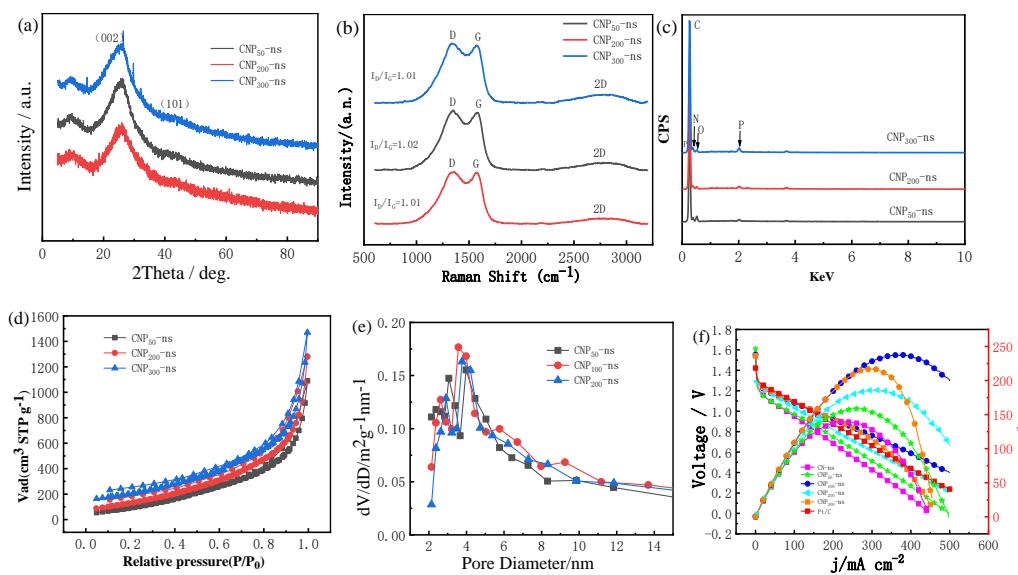


Fig.S2 XRD patterns(a);Raman spectra (b);EDS spectra(c);nitrogen adsorption-desorption isotherms(d) and corresponding pore size distributions(e) of $CNP_{50}$-ns,$CNP_{200}$-ns,$CNP_{300}$-ns; Polarization and power density curves of the Zn-air battery with the cathodic catalysts of the $CNP_{50}$-ns, $CNP_{200}$-ns and $CNP_{300}$-ns in 6 mol·$L^{-1}$ KOH(f)
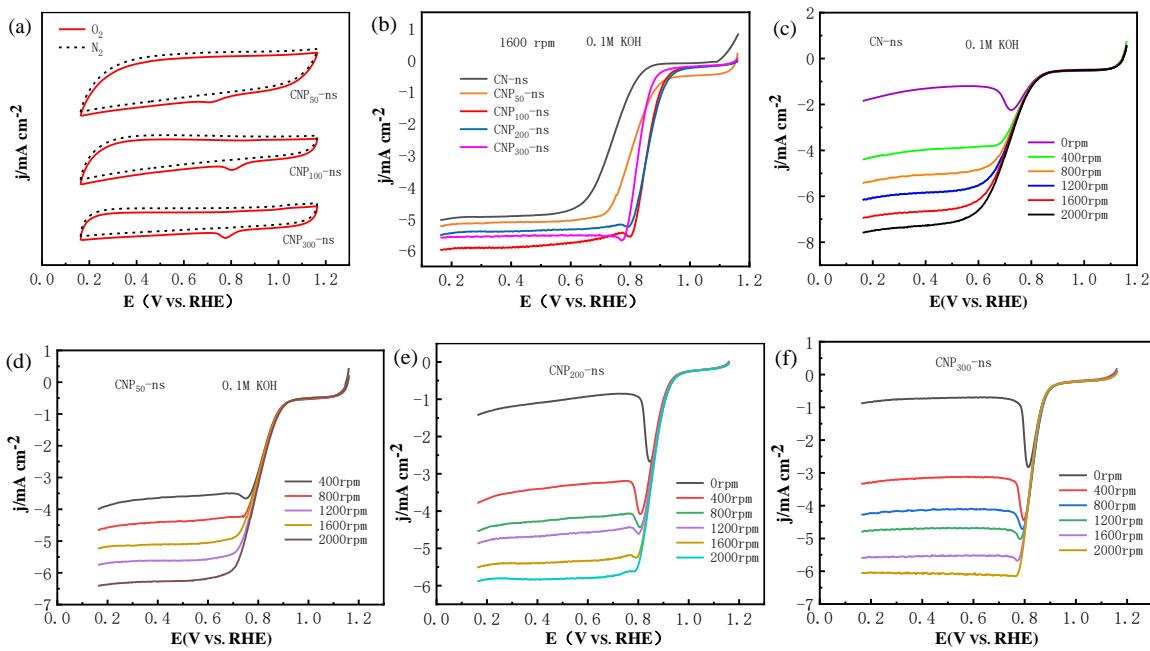
Fig.S3 CV curves of CNP$_{50}$-ns, CNP$_{200}$-ns, CNP$_{300}$-ns in O$_2$-saturated and N$_2$-saturated 0.1 mol L$^{-1}$ KOH at a scan rate of 50 mV s$^{-1}$(a). Linear polarization curves of CNP-ns catalysts and CN-ns on RDE in O$_2$-saturated 0.1 mol·L$^{-1}$ KOH at 1600rpm at 5 mV·s$^{-1}$(b); Linear polarization curves at 0rpm-2000rpm of CN-ns(c), CNP$_{50}$-ns(d), CNP$_{200}$-ns(e) and CNP$_{300}$-ns(f).

Table S1　BET characterization of all catalyst's samples

| sample | Specific surface area / (m$^2$·g$^{-1}$) | Average pore diameter / nm | Pore volume / (cm$^3$·g$^{-1}$) |
|---|---|---|---|
| CN-ns | 276.65 | 9.43 | 0.65 |
| CNP$_{50}$-ns | 396.15 | 16.83 | 2.19 |
| CNP$_{100}$-ns | 451.23 | 15.49 | 1.75 |
| CNP$_{200}$-ns | 519.87 | 16.83 | 2.19 |
| CNP$_{300}$-ns | 426.50 | 17.66 | 1.89 |
| CNP$_{100}$-ns-NaCl | 1195.29 | 11.47 | 3.43 |

Table S2 Element content of CNP-ns catalysts

| Sample | Atomic fraction / % | | | |
|---|---|---|---|---|
| | C | N | O | P |
| CNP$_{50}$-ns | 79.63 | 13.01 | 7.08 | 0.28 |
| CNP$_{100}$-ns | 82.95 | 15.64 | 1.50 | 0.31 |

| CNP$_{200}$-ns | 84.7 | 12.96 | 1.95 | 0.37 |
| CNP$_{300}$-ns | 84.85 | 13.57 | 1.05 | 0.53 |

**Table S3   ORR performance comparison**

| sample | ORR | | | | |
|---|---|---|---|---|---|
| | E$_{onset}$ (V) | E$_{1/2}$ (V) | Limiting current Density (mA cm$^{-2}$) | Tafel slope (mv dec$^{-1}$) | Reference |
| CNP-nanosheet-NaCl | 1.00 | 0.92 | 7.45 | 66 | This work |
| NPC-covalent organic polymer-900 | 0.95 | 0.84 | 5.59 | 66 | Chemical Engineering Journal, 2018, [57] |
| NPC-nanospheres | 0.98 | 0.85 | 5.21 | 74 | Carbon, 2020, [61] |
| NPC-porous networks | 0.89 | 0.82 | 4.56 | 59 | Electrochimica Acta, 2017, [62] |
| NPC- carbon spheres | 0.90 | 0.79 | 5.31 | 118 | Nano Energy, 2019, [63] |
| NPC-nanosheet-ZnCl$_2$ | 0.90 | 0.84 | 5.00 | 30 | International Journal of Hydrogen Energy, 2018, [64] |
| NPC-nanoporous carbon | 0.90 | 0.85 | 5.51 | - | Carbon, 2017, [65] |
| NPC-graphene framework | 0.91 | 0.84 | 5.62 | - | Energy & Environmental Science, 2017, [66] |