Oxygen electrocatalysts for OER and ORR are of great significance to determine the charge/discharge kinetics and energy efficiency of zinc-air batteries (ZABs). As a result, extensive research has been devoted to explore novel electrocatalysts and improve their activity for high performance ZABs. In my PhD topics, I developed a confined growth method for synthesizing porous N-doped cobalt oxide nanoarrays on carbon cloth (NP-Co$_3$O$_4$/CC). This method can effectively confine the growth of cobalt oxides, producing ultrafine Co$_3$O$_4$ nanocrystals with abundant exposed surface-active sites. Simultaneously, the Co-N bonds in Co-ZIF are introduced into cobalt oxide lattices, unprecedentedly realizing the low-temperature N doping of cobalt oxides (200 °C). As a result, the as-fabricated NP-Co$_3$O$_4$/CC-based ZABs manifest excellent performance with a very low voltage gap, ultralong cycle life, and an extremely large peak power density. Furthermore, I have developed the first BP-based metal-free bifunctional oxygen electrocatalyst by covalently bonding BP with graphitic carbon nitride (denoted BP-CN-c). The BP-CN-c catalyst presents a high OER and ORR activity. DFT calculations corroborated the vital role of interfacial P-N bonds in regulating the electron redistribution at the heterointerfaces and thus further enhance the OOH$^*$ chemisorption capability and chemical stability. Therefore, BP-CN-c based ZAB reached a high peak power density. I also developed a Zr-based single atom catalyst (Zr-N-C) for ORR because of the unique configuration and maximum atom utilization efficiency of SACs. The Zr-N-C displays a halfwave potential of 0.91V and excellent long-term durability of 92% retention after 130 h continuous operation. The Zr-N-C delivered a record high power density of 324 mW cm$^{-2}$.
Xia Wang received her Bachelor’s degree in material science and engineering in Zhengzhou university in 2014 and Master’s degree in Tsinghua university in 2017. Then she joined Prof. Xinliang Feng’s group as a PhD student and her PhD research topic is about synthesis of novel electrocatalysts for energy conversion and storage devices.