# Metal Organic Frameworks Derived Cobalt Phosphide Architecture Encapsulated into B/N Co-Doped Graphene Nanotubes for All pH Value Electrochemical Hydrogen Evolution

*Hassina Tabassum, Wenhan Guo, Rou Zhao, Asif Mahmood, Qingfei Wang, Ruqiang Zou**

Beijing Key Lab of Theory and Technology for Advanced Battery Materials, Department of Materials Science and Engineering, College of Engineering, Peking University, Beijing 100871, China.

E-mail: rzou@pku.edu.cn

## Abstract

Owing to increasing the worldwide concern over energy crisis and environmental issues, great attentions have been triggered for the development of clean and high efficient energy conversion and storage techniques by electrocatalytic reaction in recent year. As a promising candidate for the future energy supply, molecular hydrogen ($H_2$) owns the highest gravimetric energy density and produced from the electrocatalytic water splitting. The highly efficient electrocatalysts are crucial for lower overpotential to improve the energy transfer efficiency in hydrogen evolution reaction (HER). The search for highly efficient earth-abundant carbon nanomaterials with Pt-like electrocatalytic activity for oxygen reduction reaction (ORR) and hydrogen evolution reaction (HER) is still a great challenge. Herein, we present a new catalyst-free synthetic strategy of self-squeezing and rolling of B, N co-doped graphene nanosheets to nanotubes with the tunable dimensions and atomic bonds as metal-free electrocatalysts for enhancing ORR and HER using (polyethylene glycol (PEG)) as directing agent. We found that the PEG with higher molecular weight favors the formation of B, N co-doped graphene nanosheets with high-concentration of B-N bonds in carbon framework whereas the one with lower molecular weight leads to the B, N co-doped graphene nanotube (BCN nanotube) with the segregated B-C and N-C bonds. The as-prepared graphene nanostructures show the interesting atomic bonds and dimension-dependent electrocatalytic activity towards ORR and HER with BCN nanotube being the best. The BCN nanotubes show the Pt-like ORR activity, and much better ORR stability than commercial Pt/C catalyst. They also exhibit the excellent HER activity with very low overpotential and small Tafel slope of 92 mV/dec. The present work highlights the importance of tuning atomic bonds and dimensions of carbon nanomaterials for achieving highly efficient electrocatalysts for ORR and HER. Here we also concept by using B/N co-doped graphene nanotube (BCN) to confine MOF-derived CoP NPs. The developed product exhibits excellent electrochemical activity for HER in all pH value solution better than the reported non-precious metal catalyst. Moreover, catalyst shows higher stability for more than 8h. This work can be very useful to for the future integrated devices.

## Image

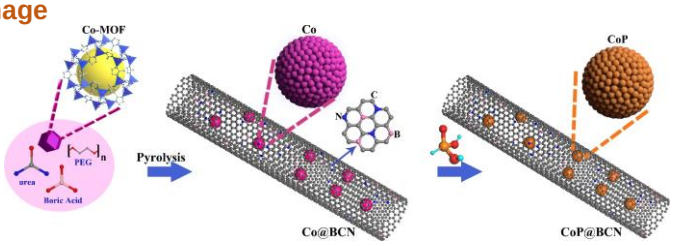



**Figure 1. Schematic illustration for the fabrication of CoP@BCN nanotubes.**

## Recent Publications

1. **Hassina Tabassum**, Ruqiang Zou,* Asif Mahmood, Zibin Liang, Shaojun Guo* "A *Catalyst-Free Synthesis of B, N Co-Doped Graphene Nanostructures with Tunable Dimensions as Highly Efficient Metal free Dual Electrocatalysts*" Journal of Materials Chemistry A, DOI: 10.1039/C6TA07214C.
2. **Hassina Tabassum**, Wenhan Guo, Rou Zhao, Asif Mahmood, Qingfei Wang, Ruqiang Zou*" *Metal Organic Frameworks Derived Cobalt Phosphide Architecture Encapsulated into B/N Co-Doped Graphene Nanotubes for All pH Value Electrochemical Hydrogen Evolution*" Advanced Energy Materials DOI: 10.1002/aenm.201601671.
3. **Hassina Tabassum**, Asif Mahmood, Qingfei Wang, Wei Xia, Zibin Liang, Bin Qiu, Ruo zhao , Ruqiang Zou*" *Hierarchical Cobalt Hydroxide and B/N Co-Doped Graphene Nanohybrids Derived from Metal-Organic Frameworks for High Energy Density Asymmetric Supercapacitors*" Scientific Report SREP-16-22912.
4. **Hassina Tabassum**, Xinyu Huang, Renjie Chen, Ruqiang Zou "*Tailoring thermal properties via synergistic effect in a multifunctional phase change composite based on methyl stearate*" Journal of Materiomics 1 (2015) 229-235.
5. Asif Mahmood, Wenhan Guo, **Hassina Tabassum**, and Ruqiang Zou*"Metal Organic Frameworks based Nanomaterials for Electrocatalysis" Advanced Energy Materials. 2016, 1600423



## Biography

Hassina Tabassum obtained her MS degree in Physics nanotechnology from International Islamic University, Pakistan. She Joined Peking University in 2013, where she is currently pursuing her PhD in Advance material and Mechanics under the supervision of Prof. Zou Ruqiang. She has published several articles in prestigious journals and her currently research area is fabrication of metal confined heteroatom doped carbon nanomaterials for energy storage and conversion devices.

Email: h.tabassum@pku.edu.cn