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Dan Wu, Zhonghai Zhang

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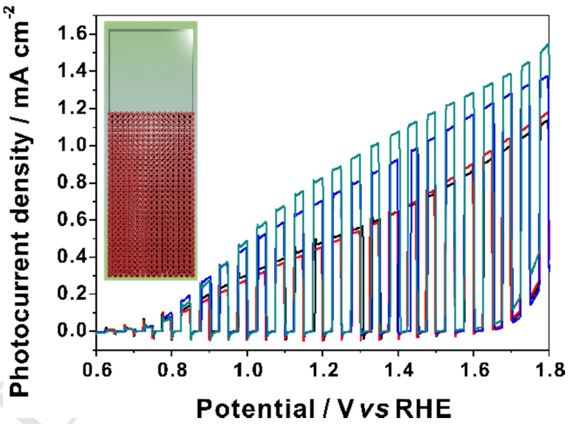
Dan Wu, Zhonghai Zhang*

School of Chemistry and Molecular Engineering, East China Normal University, Dongchuan Road 500, Shanghai 200241, China

Corresponding author. Tel: 0086-21-54345359

E-mail: zhzhang@chem.ecnu.edu.cn

Graphical abstract



Highlights

- A one-step low temperature phosphidation process is proposed.
- The P doping and CoPi decoration is simultaneously implemented on hematite
- The modified hematites present enhanced photoelectrochemical performance