Environmental Research, Technology Demonstration and Conference Project

ECF Project:	ECF 2020-84
Project Title:	Biomass-waste-derived carbon as advanced anodes for Na- and K- ion batteries
Principal Investigator:	Dr Zhang Biao, Department of Applied Physics, The Hong Kong Polytechnic University
Total Approved Grant:	$496,400
Duration:	1/6/2021 to 31/5/2023
Project Status/Remarks:	Completed
Project Scope:	Shifting from traditional fossil fuels to clean energy is critical for mitigating climate change towards a sustainable society. The practical utilisation of clean energy relies on not only the performance but also the cost of energy storage devices. This project aims to develop high-performance and low-cost Na- and K-ion batteries employing hard carbon as an advanced electrode. Compared to Li-ion batteries, the Na and K counterparts possess the advantages in sustainability due to the natural abundance of Na and K resources, making them promising candidates for stationary energy storage. To reduce the fabrication cost, biomass waste will be adopted as a precursor to prepare the carbon electrode. The specific effect of the individual constituent in biomass, such as lignin and cellulose, on the carbon formation will be explored to guide the selection and manufacture procedures of biomass for turning the waste into treasure. Successful implementation of this project will bring two-fold benefits: on the one hand, pushing forward the wide usage of clean energy; on the other hand, alleviating the burden of municipal solid waste on the valuable landfill space through recycling biomass waste.
Summary of the Findings/Outcomes:	Na- and K-ion batteries are promising complements to prevailing Li-ion batteries for large-scale energy storage. This project is devoted to developing hard carbon anodes from biomass precursors, which not only helps recycle solid waste but also reduces the battery material cost. We first screen several biomass wastes, among which the pistachio shell has been identified as one of the best candidates for preparing the hard carbon. Therefore, it is adopted as a model system to optimize the synthesis procedures, achieving attractive capacities and excellent stability for Na and K ion storage. The Na and K ion storage behavior in as-prepared carbon is explored for guiding further structure regulation. The systematic study discloses the pore-filling mechanism of K ions, providing an effective way to boost the K ion storage capacity in biomass-waste-derived hard carbon. Furthermore, we also investigate the effect of electrolytes on cyclic stability and rate performance. A cyclic ether-based electrolyte is developed, which induces the stable solid electrolyte interphase to boost the charge transfer kinetics and stabilize the electrodes. The achieves results would be benefit the rational design of hard carbon anodes from biomass waste for sustainable development.