Functional Graphene structures for Energy-conversion Devices

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We have developed a facile, reliable and reproducible electrochemical method for direct preparation of functional graphene quantum dots (GQDs), which have a uniform size of 3–5 nm and exhibit a green luminescence. The O-containing groups on the surface of GQDs makes them soluble in aqueous media, facilitating further functionalization and various applications. As a novel electron acceptor material, the as-prepared GQDs have been integrated into a P3HT based solar cell, signifi cantly enhancing the device performance. we also prepared nitrogen-doped GQDs (N-GQDs) with oxygen-rich functional groups. Unlike their N-free counterparts, the newly produced N-GQDs with a N/C atomic ratio of ca. 4.3% emit blue luminescence and possess an electrocatalytic activity comparable to that of a commercially available Pt/C catalyst for the oxygen reduction reaction (ORR) in an alkaline medium. In addition to their use as metal-free ORR catalysts in fuel cells, the superior luminescence characteristic of N-GQDs allows them to be used for biomedical imaging and other optoelectronic applications.

A new complex catalyst system of ternary Pt/PdCu nanoboxes anchored onto 3D graphene sheets has also been fabricated by a dual solvothermal process. The electrocatalytic activity of the Pt/PdCu/3DGF for ethanol oxidation are not only signifi cantly higher than that of pure Pt and PdCu electrodes, but also has an about 4-fold improvement over the well-established commercial Pt/C catalysts (E-TEK 20% Pt/C) as normalized to the total mass of active metals, which, in combination with the demonstrated single cell, shows the great potential of the geometry-defi ned Pt/PdCu/3DGF as excellent electrocatalysts for ethanol electrooxidation in alkaline media for direct ethanol fuel cells.

Furhter, a versatile, ultralight, N-doped, 3D graphene framework has been developed, which mainly consists of the network of only few graphene layers and has an ultra-low density of ca. 2.1 mg/cm^3. Its adsorption capacity is as high as 200-600 times its own weight for common pollution and organic solvents, much higher than that of the best carbonaceous sorbents reported previously. Based on the synergetic function of 3D open-pore structure and N doping, the GF supercapacitor has generated a high specific capacitance of 484 F/g, far superior to the typical carbon-based electrodes. Besides the potential as a new metalfree catalyst for efficient electrocatalytic ORR demonstrated in this study, the ultralight GF also provide an important platform for developing a variety of advanced devices, such as sensors and batteries.

References

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