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Carbon nanotube containing polyacrylonitrile materials for the oxygen evolution reaction - influence of active sites, hydrophilicity and conductivity

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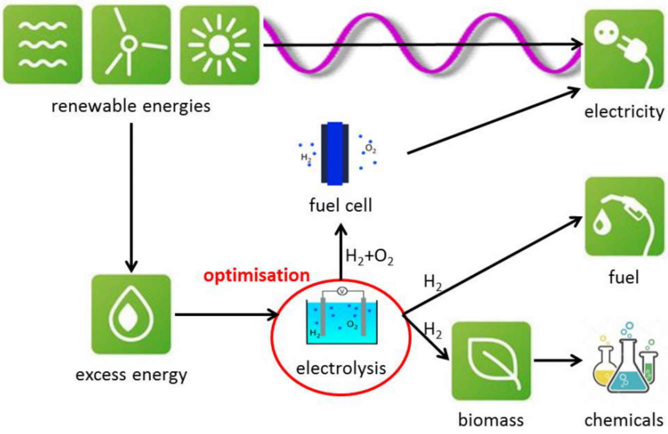
PURPOSE OF THE ABSTRACT

Hydrogen economy is one central aspect when thinking about the energy supply of the future. For an energy production that is based more and more on renewable energies conversion and storage of the fluctuating energy is highly important. If the excess energy is used to perform water electrolysis, the produced hydrogen can be used to store the energy until it is recovered in a fuel cell. Additionally, hydrogen can be used to sustainably convert bio-based feedstocks into chemicals or directly as fuel (Figure 1).
To make this process economically feasible, the limiting oxygen evolution reaction (OER) needs to be optimized.[1-2] Carbon-based electrode materials exhibit high potential as metal support or even as metal-free electrocatalysts for OER decreasing the required overpotential (OP).[3-6] Though many studies have introduced heteroatom-containing carbons or materials based on carbon nanotubes (CNT), their specific influence was barely investigated systematically. In our study composite materials of polyacrylonitrile and CNT in varying amounts were synthesised as metal-free catalysts for the OER.[7] To obtain the electrocatalyst acrylonitrile was polymerized together with CNT in an ethanol, water mixture at 70 °C using a radical starter. The polymer was dried and stabilized at 270 °C in air followed by carbonization at 800 °C under N2 atmosphere. The resulting carbon did not show a high surface area so that activation in CO2 at 900 °C was carried out to finally obtain the porous materials. The
electrode materials were fully characterized by N2- and water vapor physisorption, SEM, Raman spectroscopy, XPS, CHN analysis and XRD. Electrochemical measurements were afterwards performed in 1 M KOH solution using a glassy carbon rotating disc electrode coated with the synthesized materials as working electrode. For the best material possessing 12.8% CNT a low OP of 368 mV at 10 mA/cm2 and a high normalized activity were obtained (Figure 2).
The electro catalyst additionally showed a promising stability and a high exchange current density. The obtained results clearly emphasize that a good balance between conductivity (provided by CNT) leading to sufficient electron transfer and hydrophilicity (provided by N) leading to sufficient mass transfer are crucial to achieve an efficient metal-free OER catalyst.

FIGURES



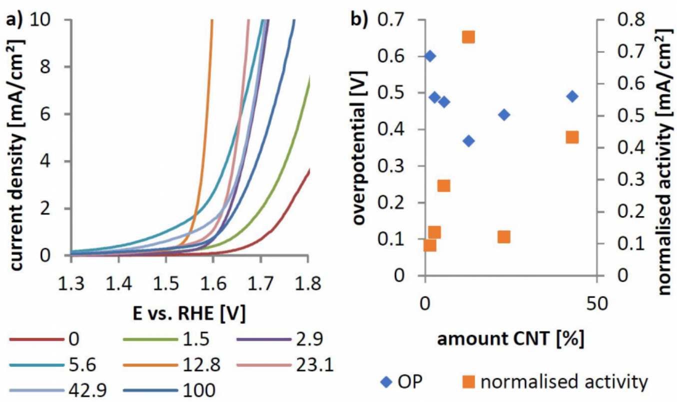


FIGURE 1

Water electrolysis as central tool for sustainable energy supply, fuel and chemicals production.

Hydrogen economy

FIGURE 2

Electrochemical measurments

a) Electrochemical activity at 10 mA/cm2, b) over potential and normalized activity of prepared PAN and CNT materials.

KEYWORDS

oxygen evolution reaction | electrochemistry | electrode materials | hydrogen production

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