Novel Cold-Plasma Induced Inorganic Network Formation in Nanohybrid Polymer Electrolytes for Water Splitting - PlaNet

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ABSTRACT

Hydrogen can become the major component of clean sustainable energy systems. The production of high purity H_2 by means of electrochemical water splitting using a Polymer Electrolyte Membrane (PEM) Electrolyser cell is a favorable method for its decentralized production. PlaNet focuses on a key core component of the electrolysis cell, the electrolyte, and proposes a new approach to develop a reinforced nanostructured organic/inorganic hybrid polymer electrolyte comprising a typical sulfonated tetrafluoroethylene structure (Nafion type) and self-assembled inorganic nanomaterials, optimizing its performance and stability.

Such an approach understands the various critical still unsolved issues concerning the current technology and aims at further progress by going beyond simple dispersion of the inorganic and aiming at the reinforcement of the polymer, as a result of a percolated inorganic network inside its structure to withstand the most challenging and corrosive environment of an electrolytic cell.

The self-assembled structure is anticipated to lead to (1) mechanical and chemical reinforcement enhancing durability under operation and (2) decreased gas crossover providing the opportunity to prepare thinner membranes that decrease the overall resistance of the electrolyte. To attain the desired structure of the inorganic within the polymer, modification of the interactions between the constituents is necessary; this will be achieved through the new approach of Cold Plasma (CP) induced modifications on the particle surface chemistry, promoting the interactions between the filler particles and/or the electrolyte-philicity. CP can be artificially generated by subjecting a neutral gas to a strong electromagnetic field to the point where an ionized gaseous substance becomes increasingly electrically conductive and long-range electromagnetic fields dominate the behaviour of the matter. It is an environmentally friendly, low cost and promising option to modify the surface chemistry of materials. CP will constitute the innovative key technology to achieve the targeted modifications.

Halloysite nanotubes (HNT) that are naturally occurring one-dimensional porous clay minerals and have a unique chemical structure were functionalized, within the framework of Planet, using Cold Plasma reactors, while attempts of chemical modification (through covalent bonding) took place for comparison as well. All materials were thoroughly characterized and subsequently the first nanocomposite electrolytes were developed.