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Professors Chanho Pak's and Jae-Suk Lee's research team develops a novel polymer binder electrode with high hydrogen ion mobility under high temperature and low humidity conditions

☐ GIST (President Kiseon Kim) School of Integrated Technology Professor Chanho Pak and School of Materials Science and Engineering Professor Jae-Suk Lee led a research team that has developed a new polymer that can be applied to high-temperature proton exchange membrane fuel cells.

☐ The high temperature proton exchange membrane fuel cell *, which is being studied for building fuel cell system, operates at lower temperatures because it operates above 120°C. However, Nafion, which is mainly used as an electrode binder ** and ionomer ***, exhibits low hydrogen ion mobility under low humidity conditions. Accordingly, the development of ionomers having high hydrogen ion mobility at high temperature has been necessary.

* high temperature proton exchange membrane fuel cell: Hydrogen ions move in a fuel cell operating at temperatures between 120°C and 180°C. Because there is no moisture, the hydrogen ions are transferred through phosphoric acid.

** binder: a polymer material that maintains the structure of fuel cell electrodes

*** ionomer: a polymer material that moves ions as reactants in fuel cell electrodes

☐ The research team developed an ionomer with high hydrogen ion mobility under high-temperature and low-humidity conditions by manufacturing a new polymer with phosphoric acid actuators. Previously, liquid phosphoric acid was infused into polymers to increase hydrogen ion conductivity, but this has the disadvantage of reduced stability due to phosphoric acid leakage. In response, the new polymer developed by the research team directly attached a phosphoric acid actuator to the polymer, enhancing the stability of the polymer.

- As the hydrogen ions move through the phosphate functional group, it was confirmed that the hydrogen ion mobility was higher at high temperature and low humidity than Nafion, which moves the hydrogen ions through the water. In addition, the hydrophobicity * increased as the side chains were analyzed using a contact angle analyzer **.

  * hydrophobicity: property that repels water and has a small affinity for water

  ** contact angle analyzer: A device that analyzes the hydrophobicity of a substance by dropping liquid droplets on the surface of the substance. The inner angle (contact angle) of the droplets on the surface of the material is measured. The greater the hydrophobicity, the higher the contact angle.

☐ The research team applied the newly developed polymer ionomer as a binder to the fuel cell electrode of the high-temperature proton exchange membrane operating at 150°C. The unit cell performance changed according to the degree of hydrogen ion movement of the ionomer and was verified by Fourier Transform embedded spectroscopy *, where the hydrogen ion migration by phosphoric acid actuators occurred.

  * Fourier transform infrared spectroscopy: A technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. Through analysis, the binding forms of molecules can be identified.

- In addition, increasing the hydrophobicity of electrodes is essential to improve the performance of high-temperature proton exchange membrane fuel cells using vinylphosphonic acid with phosphate functional groups.

- The development of new binders for high temperature proton exchange membrane fuel cells is expected to have a positive impact on the development and distribution of creating fuel cell materials and to secure new materials, thereby contributing to the creation of a hydrogen economy for society.

☐ Professor Chanho Pak said, "The biggest achievement of this study was to confirm the possibility of a new polymer binder used in the electrolyte membrane of high-temperature proton exchange membrane fuel cells and to verify the applicability to actual unit cells. In the future, this is expected to develop polymer materials for commercialization by exploring the physical properties of polymer binders and achieving process optimization for electrode formation."

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