A new high-power fuel cell operates at double the voltage of today's commercial fuel cells, according to new research.

The transportation industry is one of the largest consumers of energy in the US economy, and there is increasing demand to make it cleaner and more efficient. While more people are using electric cars, designing electric-powered planes, ships, and submarines is much harder due to power and energy requirements.

Researchers have developed a direct borohydride fuel cell that advances technology in this area. This advancement using a unique pH-gradient-enabled microscale bipolar interface (PMBI) could power a variety of transportation modes—including unpiloted underwater vehicles, drones, and eventually electric aircraft—at significantly lower cost.

"The pH-gradient-enabled microscale bipolar interface is at the heart of this technology," says Vijay Ramani, professor of energy, environmental, and chemical engineering at Washington University in St. Louis. "It allows us to run this fuel cell with liquid reactants and products in submersibles, in which neutral buoyancy is critical, while also letting us apply it in higher-power applications such as drone flight."

The fuel cell uses an acidic electrolyte at one electrode and an alkaline electrolyte at the other electrode. Typically, the acid and alkali will quickly react when brought in contact with each other. Ramani says the key breakthrough is the PMBI, which is thinner than a strand of human hair. Using membrane technology, the PMBI can keep the acid and alkali from mixing, forming a sharp pH gradient and enabling the successful operation of this system.

"Previous attempts to achieve this kind of acid-alkali separation were not able to synthesize and fully characterize the pH gradient across the PMBI," says Shrihari Sankarasubramanian, a research scientist on Ramani's team. "Using a novel electrode design in conjunction with electroanalytical techniques, we were able to unequivocally show that the acid and alkali remain separated."

"Once the PBMI synthesized using our novel membranes was proven to work effectively, we optimized the fuel cell device and identified the best operating conditions to achieve a high-performance fuel cell," adds lead author Zhongyang Wang, a doctoral candidate in Ramani's lab.

"It has been a tremendously challenging and rewarding pathway to developing the new ion-exchange membranes that has enabled the PMBI."

"This is a very promising technology, and we are now ready to move on to scaling it up for applications in both submersibles and drones," Ramani says.

The research appears in *Nature Energy*. The Office of Naval Research, Washington University in St. Louis, and the Institute of Materials Science & Engineering at Washington University in St. Louis supported the study. The team is working with the university's Office of Technology Management to explore commercialization opportunities.

Source: Washington University in St. Louis