Research team designs a cutting-edge protein 'lawnmower'

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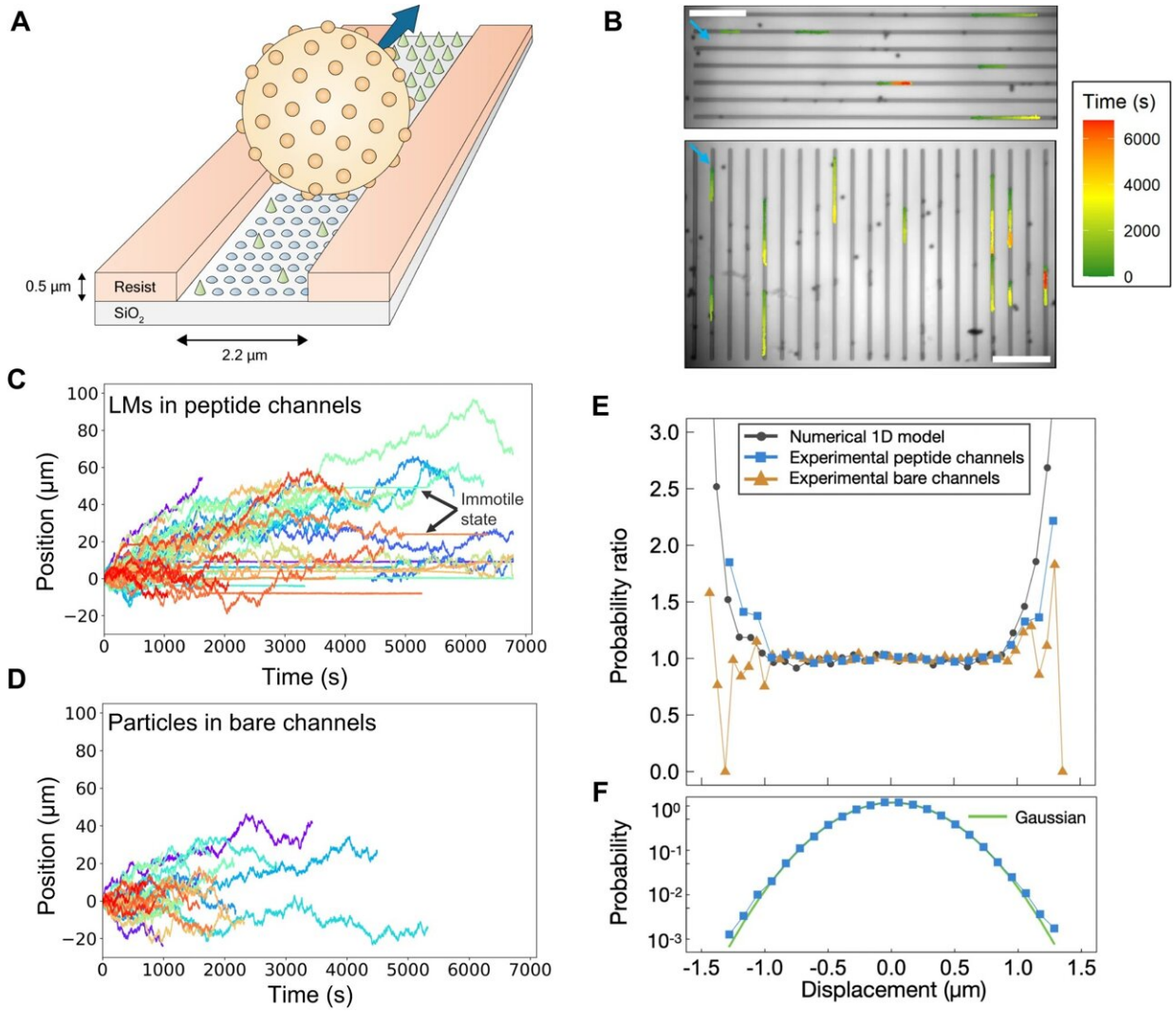

Lawnmowers exhibit track-guided motion. **A** Schematic illustrating LM motion within a lithographically defined peptide-containing channel with polymer resist walls and a SiO_2 channel floor that was selectively functionalized. LM beads

have a density of 1.6 g/cm^3 and are partially confined to the inside of channels by gravity. Channels are patterned in two directions as a control for possible background flow. **B** Trajectories of LMs on peptide lawns, colored from green to red to illustrate the time course of motion. Trajectories are overlaid with an image of the orthogonally patterned channels in the beginning of imaging (trajectories that started later are not depicted). The light blue arrows show the direction of slight background flow (≈ 0.01 μm/s). Scale bar is 50 μm. **C**, **D** Position along the channel direction as a function of time for (**C**) $n = 48$ LMs in peptide channels and (**D**) $n = 26$ particles in bare channels. The starting position of each LM is plotted with a common origin, with the positive direction chosen to align with the observed background flow in the channel. **E**, **F** Displacement distributions relative to Gaussian distributions. **E** Comparison of experimental and model results to Gaussian distributions. Plotted are the ratios of probability densities for the measured versus Gaussian-predicted distributions, where the first and second moments of the Gaussian distribution match experiment. Blue squares: peptide lawn from (**C**). Orange triangles: bare lawn from (**D**). Black circles: 1D LM model. The model captures the heavy tails seen for LMs on peptide lawns, while bare lawn trajectories are described by diffusion. **F** Displacement probability distribution of LMs in peptide channels has heavier tails than a Gaussian distribution, as seen also by the kurtosis of the distribution of $\kappa = 3.3$. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-45570-y

An SFU-led collaboration has designed the first synthetic protein-based motor that harnesses biological reactions to fuel and propel itself.

"Imagine if a Roomba could be powered only by the dirt it picks up," says SFU Physics professor Nancy Forde, one of the authors of the study.

The team's paper, led by SFU Physics Ph.D. graduate Chapin Korosec and published in *Nature Communications*, describes a protein-based molecular motor called "The Lawnmower," which has been designed to

cut a lawn of peptide "grass." The motor uses the digestive enzyme trypsin to cut the peptides and convert them into the energy it needs to propel itself.

The researchers at SFU and in Lund, Sweden demonstrated that the Lawnmower is capable of self-guided motion and can be directed in specific directions using a specially designed track, an important step towards their implementation in a variety of settings.

The team's findings build on decades of research on the role and function of molecular motors in organisms. As the researchers explain, all living systems, from humans to plants to bacteria, are kept alive by protein-based molecular motors. These motors convert chemical energy from one form into another to do useful work such as facilitating cell division, delivering cargo, swimming towards food or light, and maintaining healthy tissues.

The Lawnmower is the first artificial motor device created with proteins from nature. As Forde explains, these experiments help researchers test our understanding of how molecular motors work in nature.

"If the rules that we've learned from studying nature's molecular motors are correct and sufficient, then we should be able to build motors out of different protein parts and have them work in expected ways," she says.

In the future molecular motors may have important applications in medicine and biocomputing. In the human body, motor proteins are especially important for transporting cargo within neurons. Knowing how these molecular machines work may be key to understanding and treating motoneuron diseases such as multiple sclerosis and spastic paraplegia.

Molecular machines designed to mimic biological processes may also

help health care providers deliver more targeted treatment for diseases.

"Influenza is thought to work as a molecular motor to infiltrate the area around cells in order to infect them," Forde says. "Maybe synthetic motors could use the same approach, but rather than infecting cells, they could be engineered to deliver drug payloads to specifically target diseased cells."

"We are inspired by the Nobel-prize-winning physicist, Richard Feynman, who famously wrote 'What I cannot create, I do not understand.' Our team's work aims to test our understanding of the fundamental operational principles of molecular machines by trying to create them from scratch."

More information: Chapin S. Korosec et al, Motility of an autonomous protein-based artificial motor that operates via a burnt-bridge principle, *Nature Communications* (2024). DOI: 10.1038/s41467-024-45570-y

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