Water sprinkled on a Teflon-coated frying pan will bead up instead of spreading out. Apply this same Teflon coating to a thin wire, though, and water droplets might take things one step further, actually launching themselves off of the water-repelling surface.

In a recent issue of Physical Review Letters, researchers report that under certain conditions, small droplets of water on a hydrophobic fiber will join together to form larger droplets before propelling themselves off of the surface. A surface that self-cleans in this way—that is, rids itself of a liquid without the application of an external force—could have numerous potential applications in industry, where processes like oil refinery and water filtration rely on efficient separation of materials.

According to Chuan-Hua Chen, the Duke University researcher who led the project, the investigation was sparked when students in his laboratory noticed that certain insects’ wings were coated with fine hairs that seemed to allow water droplets to bounce off of them. At first, the students thought their observation was no more than an artifact—their previous research had demonstrated that droplets could propel themselves off of specially designed nanotextured superhydrophobic surfaces, but not an ordinary hydrophobic one. (Superhydrophobic surfaces repel water to an extreme degree.)

When the researchers looked further, though, they found that the effect might really exist. To test the idea, Chen and his team coated copper wires with Teflon. Teflon is somewhat hydrophobic—one reason why it works well for non-stick cookware—but is not superhydrophobic like other surfaces that have previously demonstrated a bouncing droplet effect.

The research team cooled the wires below the dew point, inducing water vapor in the air to condense on the wires’ surface. The small condensate drops quickly merged together to form larger ones, some of which launched themselves from the fiber (see video).

The researchers attributed the bouncing droplets’ to two factors: the curvature of the fiber surface and the diameter of the droplets relative to the fiber. When two drops of water on a surface coalesce into one larger drop, their surface area decreases but their mass stays the same, resulting in a release of energy. If the droplets are on a thin, curved fiber instead of a large flat surface, they have less area in contact with the surface. In the case of the Teflon-coated
wires, the energy released from the droplets coalescing was enough to
overpower the forces holding them to the surface and kick them off.

The team also determined that by adjusting the diameter of the fiber, they
could control what size of droplets jumped off. “The drop size needs to be a
few times larger than fiber size before departure occurs,” says Chen—one
reason the effect is not seen on a flat hydrophobic surface.

The hydrophobic fibers could eventually be used in industrial-scale coalescers,
used to separate materials during oil purification, water purification, and
numerous other applications. These industrial coalescers generally work by
gathering small droplets into larger ones, and then waiting for gravity to drain
them from the surface. However, these systems can easily clog if too much
water accumulates or if the surface is not oriented such that it can readily
drain. A setup where the liquid removed itself, as observed on Chen’s
microfibers, could help overcome these limitations.

While the bouncing droplet effect has been observed before on
superhydrophobic surfaces, Chen says that hydrophobic fibers are a more
durable prospect for long-term use in industry. A superhydrophobic surface
might perform spectacularly in laboratory tests, but the fine nanoscale
texturing that makes it work could get clogged with small droplets over time
and cease to function.

“The nano-texture and common hydrophobic promoters are very susceptible
to damage, which currently limits the use of superhydrophobic surfaces for
condensation applications,” says Konrad Rykaczewski, a researcher at Arizona
State University who was not involved in the research. “In [contrast], the
latest work by Professor Chen and co-workers shows that properly sized
microfibers...could be used to effectively condense/collect and remove micro
droplets.”

Read the abstract in Physical Review Letters.