Electronic Supplementary Material (ESI) for Soft Matter.

Lotus-like Effect for Metal Filings Recovery and Particle Removal on Heated Metal Surfaces Using Leidenfrost Water Droplets

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Fe Filings. The size of the Fe filings were measured using scanning electron microscopy (SEM) as shown in Figure S1 below.

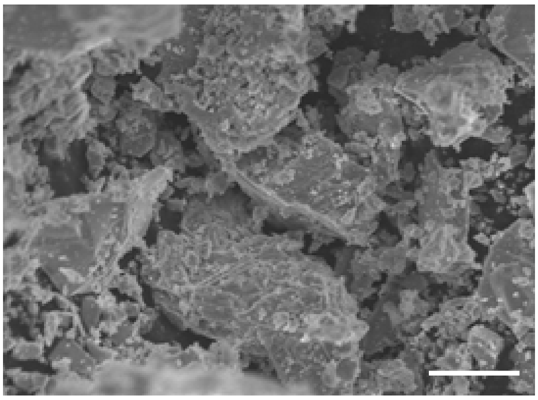

Figure S1: SEM image of Fe filings. Scale bar = 10 μm.

Particle Size After Aggregation. The size of activated carbon (AC), Cu, SiO_2, and Fe is given in Figure S2.

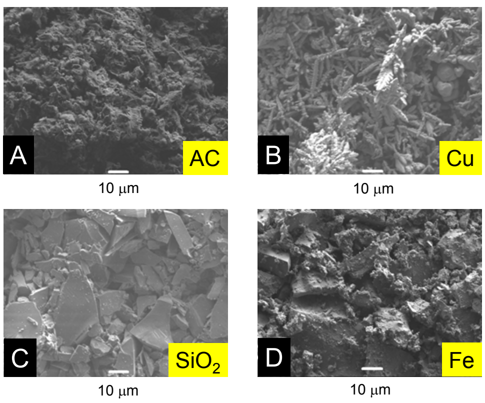

Figure S2: SEM images of AC, Cu, SiO_2, and Fe particles after the Leidenfrost effect. Scale bar = 10 μm.

Hydrophilic Materials. Hydrophilic particles of MgO and SiO_2 were placed on a flat heated Al surface. Water droplets were then added to the surface and the particles were allowed to reconcentrate via the Leidenfrost effect. Figure S3 shows the process whereby the nanoparticles collect on the surface of the Leidenfrost droplet, see panels A-D. The collected SiO_2 particulates aggregate into a compact hemisphere upon water evaporation, as observed in panels E-F. Similarly, a mixture of MgO and Fe filings was successfully reconcentrated into a compact aggregate upon solvent evaporation through the use of the Leidenfrost effect, as shown in Figure S4 below.

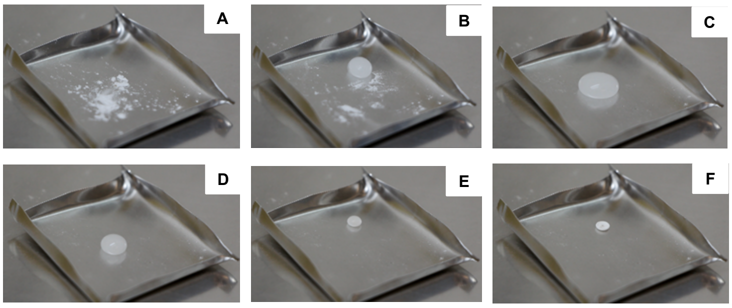

Figure S3: Use of the Leidenfrost effect to reconcentrate SiO_2 particles into a compact solid aggregate.

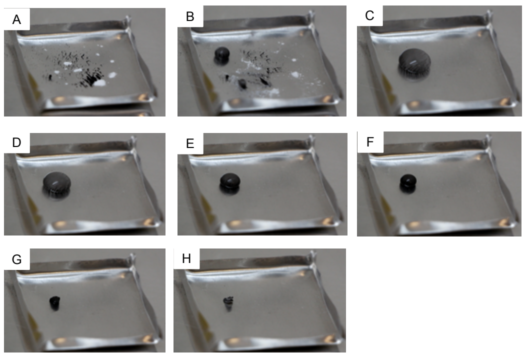

Figure S4: Use of the Leidenfrost effect in aggregating a mixture of Fe filings and MgO particles.

Hydrophobic Materials. The Leidenfrost effect can remove hydrophobic materials from metallic surfaces. Figure S5 shows the ability of the Leidenfrost phenomena to reconcentrate dust particles of varying size and hydrophobic activated carbon (AC) from heated Al surfaces in an effective manner. As observed from panels A4 and B4, dust particles and AC particles are both suspended on the surface of the droplet, resulting in a material-free surface. Figure S6 shows the complete removal of a mix of dust particles and hydrophobic activated carbon nanoparticles from a heated Al surface, as shown in panels A-I. Panels A-E display the process whereby the material mixture is collected by the Leidenfrost droplets through the continuous addition of water. It is observed in panel F that upon the evaporation of water, the material reconcentrates into an oval-shaped aggregate. Since the initial mixture was sprinkled with Fe filings, the entire aggregate of material comprising the dust particles and the hydrophilic activated carbon nanoparticles is magnetized. Therefore, the aggregate can be collected up via a rare-earth magnet, as shown in panels G-I.

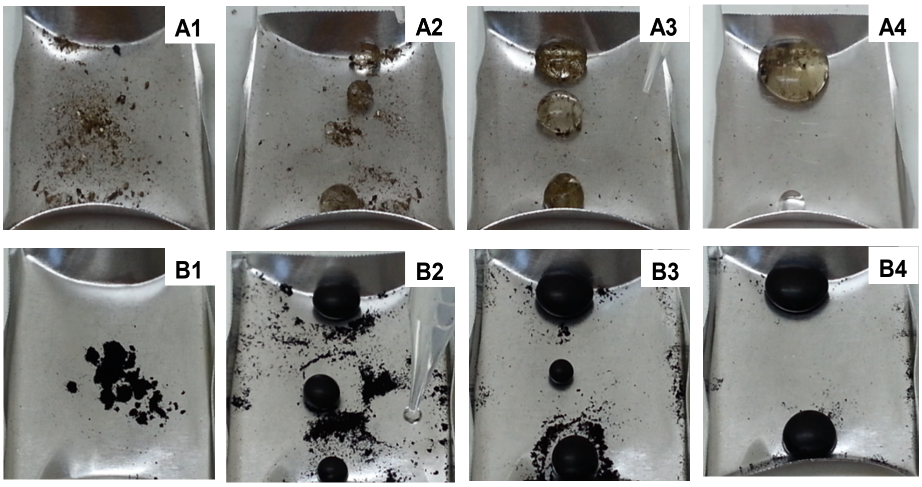

Figure S5: Panel A (1-4) progressively shows the ability of the Leidenfrost effect to collect the dust particles around the droplet. Panel B (1-4) displays the removal of the hydrophilic activated carbon nanoparticles from the surface and reconcentration around the droplet. During the procedure, ionized water was continuously added in set volume amounts of 5 μL.

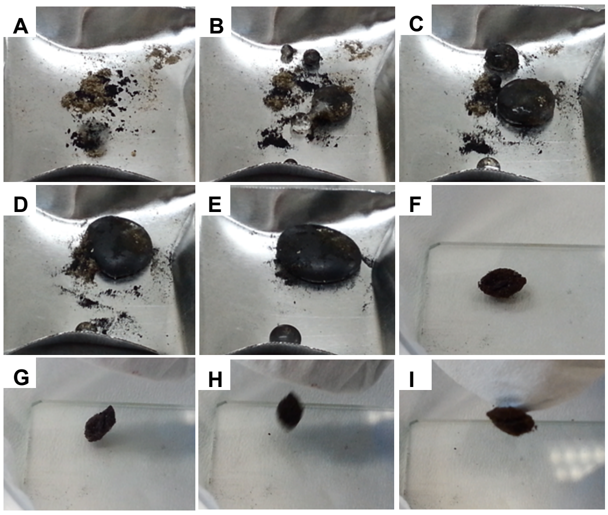

Figure S6: Panels A-F show the complete surface cleaning process from a mixture of dust particles and hydrophilic activated carbon nanoparticles through the Leidenfrost effect, while the use of a rare-earth magnet to remove the dried aggregate from the surface can be observed in panels G-I.

Grooved Surfaces. The effect of surface roughness is shown in Figure S7. Panels A-F exhibit the cleaning process of removing various materials from an Al patterned surface by utilizing the Leidenfrost effect. Of particular interest is the observation that the surface remains notably devoid of particulates, which is a direct indication of the powerful "vacuuming" ability of the vapor layer film in collecting the particles from the heated surface. The bulk of the dust and Fe particles were removed from the surface except for a small amount of mostly Fe filings that remained in the grooves. Since the surface is no longer smooth and even, smaller particles tend to get trapped in the channels. Due to the depth of the channels of ~ 500 μm the contact area between the particles and the vapor layer film is reduced. As a result, van der Waals interactions between the droplet and the particles are not strong enough for the particles to be lifted up out of the grooves.

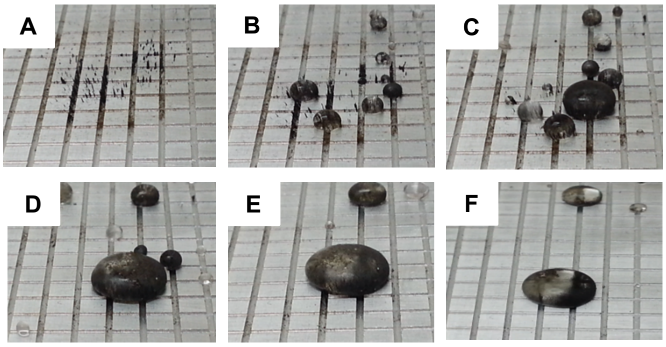

Figure S7: Panels A-F show the cleaning process of an Al patterned surface utilizing the Leidenfrost effect. The reconcentrated material was comprised of dust particles and Fe filings. The patterned lines in the Al measured ~2 mm width × 0.5 mm in depth.

Particle Aggregation by the Leidenfrost Water Droplets. Top and side view images of activated carbon, dust, and SiO_2 reconcentrated materials can be found in Figure S8. The scale bar is 1 mm. The shape of the aggregated material correlates with the initial amount utilized. For instance, the larger quantity of activated carbon dries up in a hemispherical shape (panel A), as do the dust fibers (panel B), while SiO_2 (panel C) and Cu (panel D) follows the surface contour of the lower half of a water droplet because less material was initially used during the experiment.

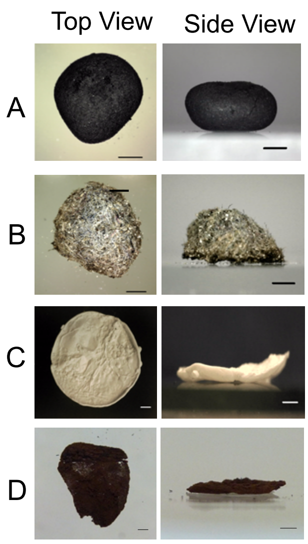

Figure S8: Optical images of top (left) and side (right) view of (A) activated carbon, (B) dust fibers, (c) SiO_2 and (d) Cu filings. Scale bar = 1 mm.

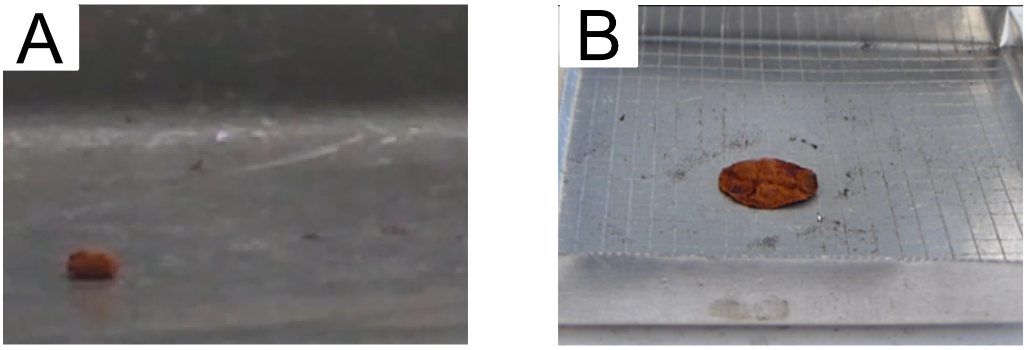

Figure S9: Final geometry of the aggregated material as a function of initial Leidenfrost droplet size. In panel A, the material was aggregated by initial water Leidenfrost droplet (~5 μL), while in panel B, the initial Leidenfrost droplet was 25 μL and produced a flat "pancake" aggregation.

Soluble Salts

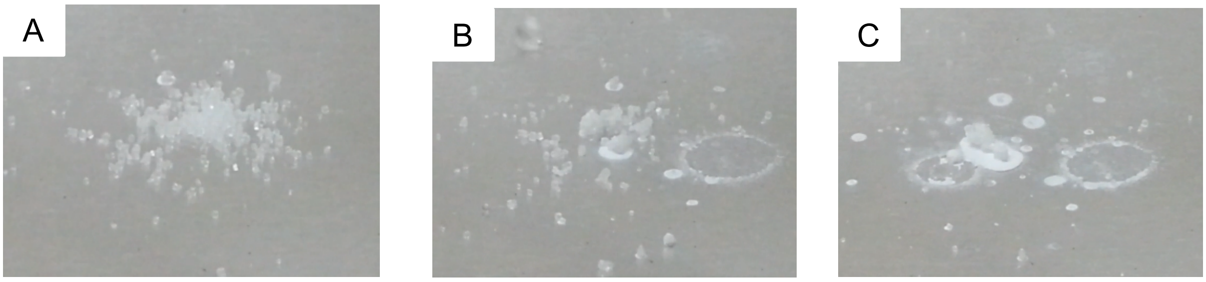

Figure S10: (A) shows NaCl crystals on a heated Al surface. (B-C) displays white residue on the heated Al surface after the Leidenfrost droplet collapsed and boiled off rapidly.

Particle Layer Thickness

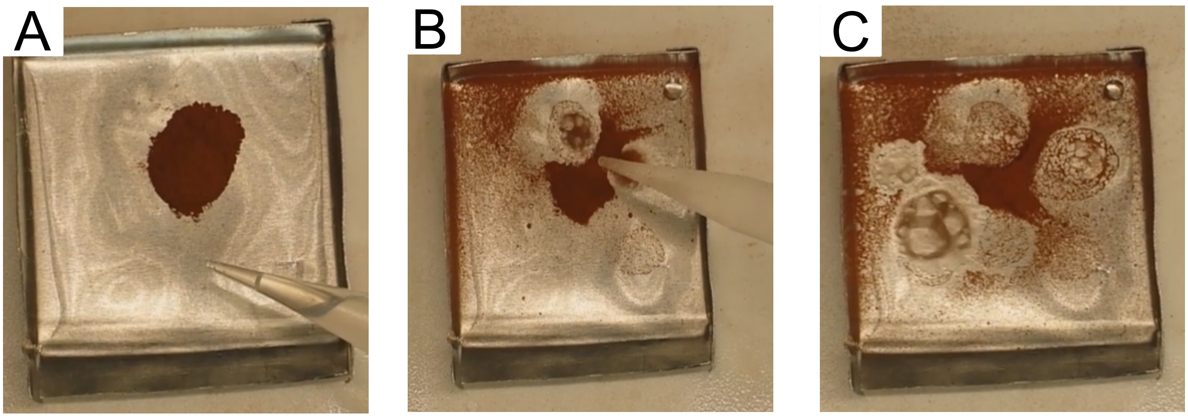

Figure S11: Panels A, B, C show the effect of a Cu particle layer ~2 mm thick in raising the Leidenfrost temperature. No Leidenfrost droplet forms, but instead the water droplet boils off. The metal surface temperature was maintained at 240 °C.