

Supporting information

Anti-scaling magnetic slippery surfaces

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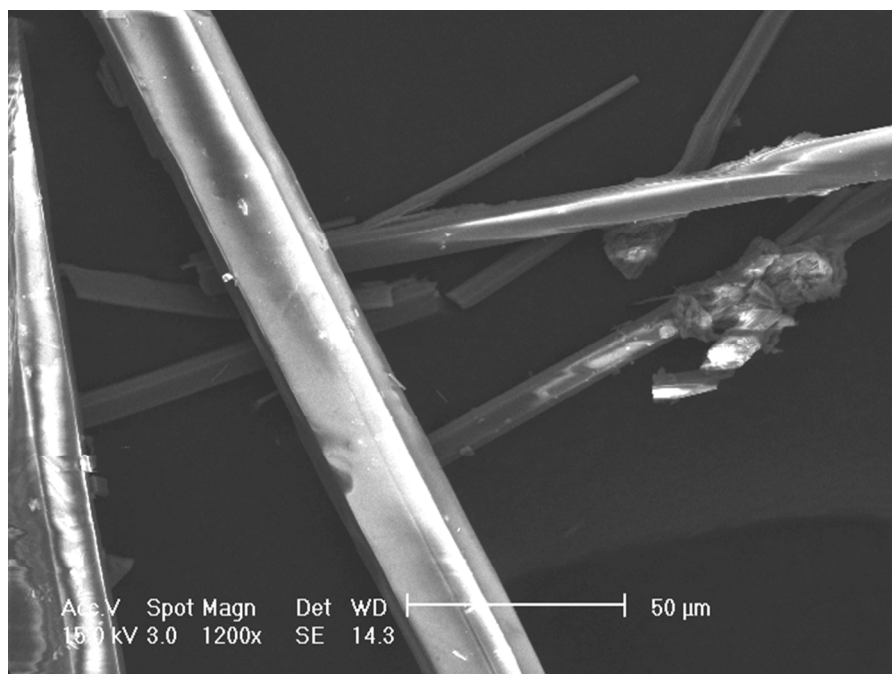


Figure S1. Structure of needle-like calcium sulfate scale formed on the samples is shown.

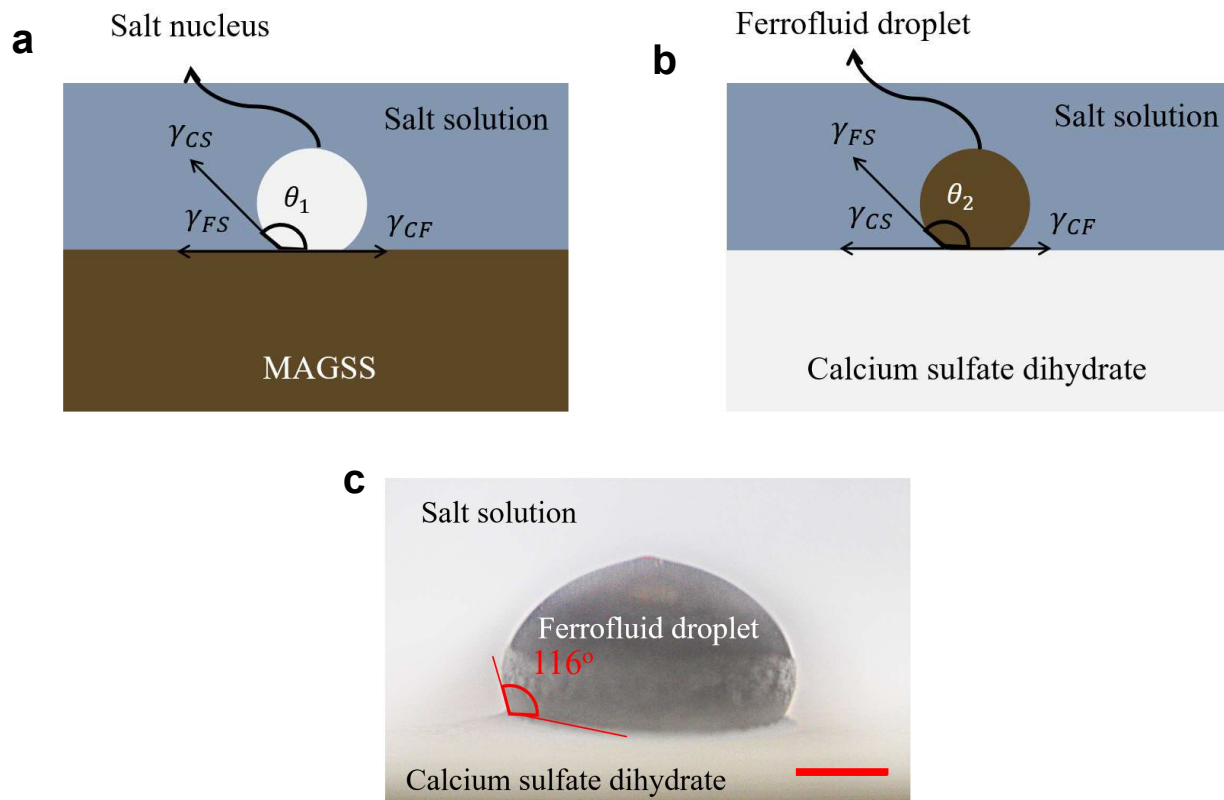


Figure S2. (a) Schematic of salt nucleation on MAGSS in a liquid salt solution (b) Schematic of contact angle and interfacial forces for a ferrofluid droplet on a salt substrate in a liquid salt solution (c) Demonstration of ferrofluid droplet contact angle on the salt substrate in a liquid salt solution environment. The error in contact angle measurements was 5° . The scale bar is 1 mm.

The method for determination of Gibbs energy barrier for scale nucleation on liquid-liquid interfaces

To determine value of f function, one needs to determine the value of m and x . The $f(m,x)$ function is written as¹

$$f(m, x) = \frac{1}{2} \left\{ 1 + \left(\frac{1 - mx}{g} \right)^3 + x^3 \left[2 - 3 \left(\frac{x - m}{g} \right) + \left(\frac{x - m}{g} \right)^3 \right] + 3mx^2 \left(\frac{x - m}{g} - 1 \right) \right\} \quad (S1)$$

Where

$$g = (1 + x^2 - 2mx)^{1/2} \quad (S2)$$

and $m = \cos(\theta_1)$, $x = \frac{R}{r_c}$, and $r_c = \frac{2\gamma_l}{\Delta G_v}$, where R denotes radius of roughness at the surface, r_c the critical nucleus size, γ_l the interfacial tension of nucleus-liquid and ΔG_v the volumetric free energy of phase-change.

As the developed MAGSS surface is smooth at the molecular scale, the value of $x \gg 1$. In this regime, function f becomes independent of x and only value of m is required to determine f value. Here, we have developed an approach to determine the value of m . We consider two cases as shown in **Figure S2 (a) and (b)**. The first case considers a salt nucleus on MAGSS and the second case considers a droplet of ferrofluid on the calcium sulfate salt substrate. For both cases the medium is a saturated salt solution. The interfacial force balance equations are written as

$$\gamma_{CF} - \gamma_{FS} + \gamma_{CS} \cos \theta_1 = 0 \quad (S3)$$

$$\gamma_{CF} - \gamma_{CS} + \gamma_{FS} \cos \theta_2 = 0 \quad (\text{S4})$$

Where γ_{CF} is the calcium sulfate salt nucleus-MAGSS interfacial tension, γ_{FS} is the MAGSS (ferrofluid)-salt solution interfacial tension, and γ_{CS} the interfacial tension of calcium salt nucleolus-saturated liquid. By subtraction of these two equations and knowing $m = \cos \theta_1$, one finds

$$m = (1 + \cos \theta_2) \left(\frac{\gamma_{FS}}{\gamma_{CS}} \right) - 1 \quad (\text{S5})$$

We developed an experimental setup to measure θ_2 as shown in **Figure S2 (c)**. Smooth layer of salt was placed at the bottom of beaker and then filled with 100 ml of saturated solution. We tried to develop a smooth surface and eliminate the role of roughness on the contact angle. A droplet of 0.01 ml ferrofluid was deposited on the salt substrate. The contact angle of ferrofluid droplet on salt (θ_2) in a salt solution medium was measured with a digital camera (Canon DSLR) as shown in **Figure S2 (c)**. We conducted this experiment for more than five times to obtain an average value of contact angle. The standard deviation of measured contact angles was 5° . The value of γ_{FS} was measured as $22.8 \pm 0.1 \text{ mNm}^{-1}$ with Tensiometer (Biolin Scientific, Sigma 701). Value of γ_{CS} is reported as 95 mNm^{-1} .^{2,3} Having all these parameters, we found that the value of $m = -0.86 \pm 0.02$ and function of $f(m, x)$ through Equation S1 is 0.98 ± 0.02 .

References

- (1) Fletcher, N. H. Size Effect in Heterogeneous Nucleation. *J. Chem. Phys.* **1958**, 29, 572.
- (2) Nielsen, A. E. *Kinetics of Precipitation*; Pergamon Press: Oxford, 1964.
- (3) Nielsen, A. E.; Sohnel, O. Interfacial Tensions Electrolyte Crystal-aqueous Solution, from Nucleation Data. *J. Cryst. Growth* **1971**, 11, 233–242.