Supplementary Information for

Silicone Oil Impregnated Nano Silica Modified Glass Surface and Influence of Environmental Dust Particles on Optical Transmittance

Bekir Sami Yilbas[a,b], Muhammad Rizwan Yousaf[b], Abdullah Al-Sharafi[b], Haider Ali[b], Fahad Al-Sulaiman[a,b], Numan Abu-Dheir[b], Mazen Khaled[c] and Nasser Al-Aqeeli[b]

a. Center of Excellence in Renewable Energy, King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia.
b. Mechanical Engineering Department, King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia.
c. Chemistry Department, King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia.

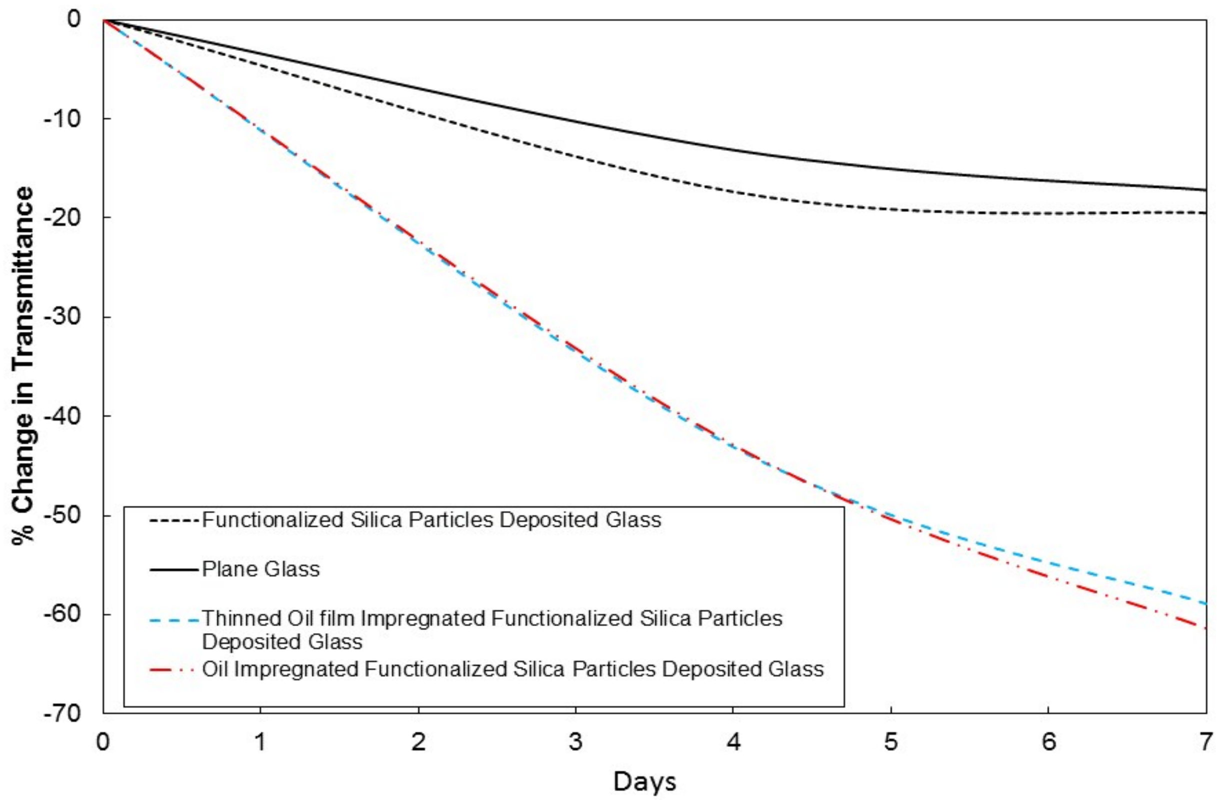

Fig. S1 Percentage of change of UV-visible transmittance of functionalized silica deposited surface after outdoor tests. (Percentage of Transmittance Change $= (T_{AT} - T_o)/T_o$, where To is the average transmittance prior to the outdoor tests and TAT is the average transmittance after the outdoor tests.

S1. Analysis for force balance of immersing dust particle into silicone oil

Consider oil impregnated film and immersion of spherical dust particles takes place along the depth h be in line with Fig. S2.

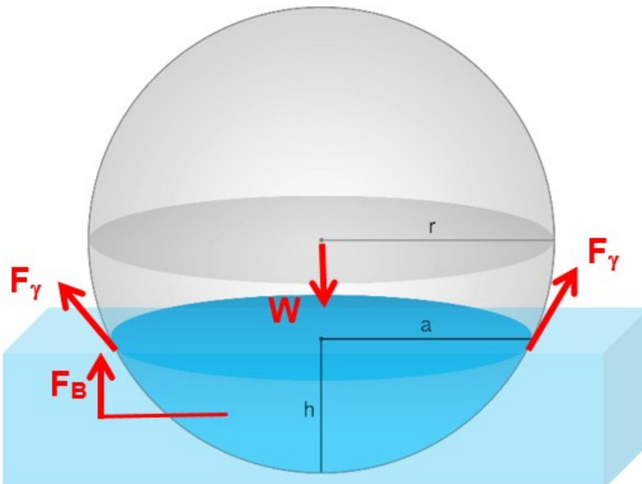

Fig. S2 Partially immersed spherical particle and forces acting on a particle. The blue region represents oil.

Geometric variables r, L, and a can be defined through Fig. S2. The volume of a dust particle (V_{total}) and volume displaced by fluid ($V_{displaced}$) can be determined from Fig. S2, i.e.: consider the followings:

$$L = 2\pi a \tag{S1}$$

where L is the interfacial length (contact length) between particle and oil surface. Total volume of the spherical particle is:

$$V_{total} = (4\pi/3)r^3 \tag{S2}$$

where r is radius of the spherical particle. The volume displaced of oil due to particle immersion is:

$$V_{displaced} = (\pi/3)h^2(3r - h) \tag{S3}$$

Geometric relations can be obtained from Fig. S2, i.e., the following expression can be written:

$$a = \sqrt{r^2 - (r - h)^2} \tag{S4}$$

Vertical force acting on a spherical particle yields force balance, i.e.,

$$F_{Resultant} = F_B + F_\gamma sin\theta - W \tag{S5}$$

where, F_B ($F_B = \gamma_{fluid}V_{displaced}$) is the buoyancy force, F_γ ($F_\gamma = \sigma L$ is the surface tension force, σ is surface tension, and W ($W = \gamma_{particle}V_{total}$) is the weight of spherical particle.

From force balance one can derive an expression for displacement (h), for which spherical dust particle immerses into oil, in terms of time (t). In this case, force balance yields:

$$\sum F = F_{Resultant} = ma \tag{S6}$$

Here the positive direction is taken upward.

Let mass of spherical particle is ($ma = \rho V_{total}(d^2h/dt^2)$, where ρ is density of particle. After substituting vertical force balance in Eq. S6, it yields:

$$\rho V_{total}(d^2h/dt^2) = F_B + F_\sigma sin\vartheta - W \tag{S7}$$

Substituting the expressions of forces from above, one can obtain:

$$\rho V_{total}(d^2h/dt^2) = \gamma_{fluid}V_{displaced} + \sigma L sin\theta - \gamma_{particle}V_{total} \tag{S8}$$

where L = 2πa and a = $\sqrt{r^2 - (r-h)^2}$.

Substituting expression for volume and length, which are all functions of h, one can get:

$$\rho(4\pi/3)r^3(d^2h/dt^2) = \begin{cases} \gamma_{fluid}\left(\frac{\pi}{2}\right)h^2(3r-h) + \sigma sin\vartheta 2\pi\sqrt{r^2-(r-h)^2} \\ \quad - \gamma_{particle}(4\pi/3)r^3 \end{cases} \tag{S9}$$

Rearranging and expanding the right side of Eq. S9, it yields:

$$\frac{d^2h}{dt^2} = -\gamma_{fluid}\frac{1}{4\rho r^3}h^3 + \frac{3}{4\rho r^2}\gamma_{fluid}h^2 + \frac{3}{2\rho r^3}\sigma sin\theta\sqrt{r^2-(r-h)^2} - \frac{\gamma_{particle}}{\rho} \tag{S10}$$

Eq. S10 is a nonlinear second-order ordinary differential equation. Eq. S10 can be solved numerically after introducing the appropriate initial conditions, such as at $t = 0 \Rightarrow h = 0$ and dh/dt = 0.

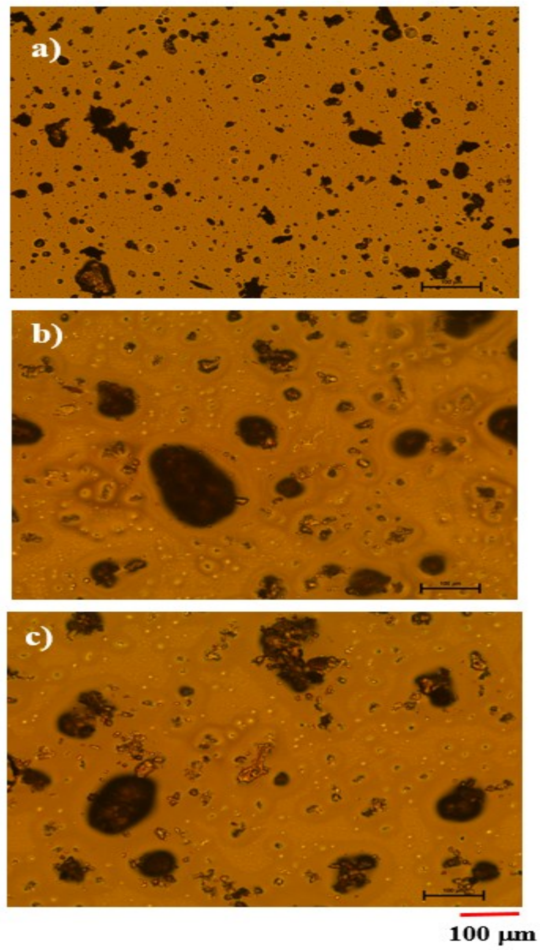

Fig. S3 Optical images of dust particles settled on glass and oil impregnation of functionalized silica particles deposited glass surface: a) glass surface, b) thick layer (700 nm) of oil impregnated functionalized silica particles deposited glass surface, and c) thin layer (56.2 nm) of oil impregnated functionalized silica particles deposited glass surface.