Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supplementary Information

<u>Calculation of Surface area increase due to hexagonal-packed Polystyrene Spheres (PS)</u>

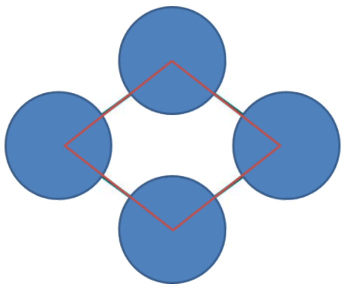

Figure 1. hexagonal packing of PS.

Assuming that the PS is essentially hemispheres on the substrate, then considering the area confined by the red lines in figure 1 we get the area that can be covered by nanorods with and without polystyrene spheres.:

1. Without PS:

$$S_{ns} = \cos 60^{o} \times 800^{2} = 5.54 \times 10^{5}\, nm^{2}$$

2. With PS:

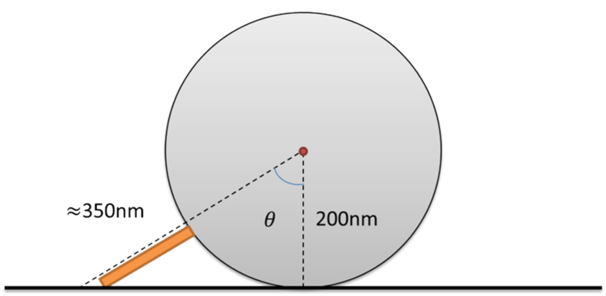

Figure 2. Side view of a PS with a NR on the edge of grown region on PS.

The increased area due to PS is the region that can develop a full-length NanoRod (NR). Assume the length of single NR, l_{NR}, is 150 nm and the diameter of PS is 400 nm (200 nm in radius, r_{PS}).

The angle between the edge of grown region on PS and the normal to the substrate surface, θ, (figure 2) is 0.963 radians:

The grown area on a single PS is:

$$S_{ps} = 4\pi r_{ps}^{2} - \int_{0}^{0.963} 2\pi r_{ps}^{2} \sin\theta d\theta = 3.96 \times 10^{5}\, nm^{2}$$

The area where NRs can grow now becomes:

$$S_{N}^{'} = S_{ns} + S_{ps} - \text{area blocked by the PS} = 5.54 \times 10^{5} + 3.96 \times 10^{5} - \pi (r_{ps} + l_{nr})^{2} = 5.65 \times 10^{5}\, nm^{2}$$

Hence the ratio of surface areas where nanorods can grow is given by:

$$\frac{S_N^{'}}{S_{np}} = 1.02$$

Increase in surface area for fluorophore attachment

SEM images can now be used to find the areal density for both the nanorods and nanoflower arrays.

For aligned nanorods (NRs):

The counted areal density of NRs, ρ_{NR}, is found to be 1.04 x 10^{-4} nanorods.nm^2

The fraction of the surface area that can be used for growing nanorods, f_{nrs} is:

$$f_{nrs} = \frac{S_{np}.\rho_{NR}.\pi r_{nr}^2}{S_{np}} = 0.523$$

Where r_{nr} is the radius of the nanorods

Hence we can now find a value of the surface area that fluorophores can attach given by:

$$S_{NR}^{'} = (1 - f_{nrs})S_{np} + S_{np}\rho_{NR}(2\pi r_{nr}l_{nr} + \pi r_{nr}^2) = 3.17 \times 10^6\, nm^2$$

The ratio of available surface areas where fluorophores can attach is now given by:

$$\frac{S_{NR}^{''}}{S_{np}} = 5.7$$

For Nanoflowers (NF):

Since $\frac{S_N^{'}}{S_{np}} = 1.02$ the projection area of $S_N^{'}$ is approximately the same as that without PS when counting the areal density of NRs on the PS that form the nanoflowers (NF).

In this case counted areal density of nanorods, ρ_{NRF} is 1.65 x 10^{-4} nanorods.nm^{-2}.

The fraction of the surface area that can be used for growing nanorods as nanoflowers, f_{nfs} is:

$$f_{nfs} = \frac{S_{np}.\rho_{NRF}.\pi r_{nrf}^2}{S_{np}} = 0.467$$

Where r_{nrf} is the radius of the nanorods used in the nanoflower array.

Hence we can now find a value of the surface area that fluorophores can attach given by:

$$S'_{NF} = (1 - f_{nfs})S_{np} + S_{np}\rho_{NRF}(2\pi r_{nrf} l_{nrf} + \pi r_{nrf}^2) = 3.20 \times 10^6 nm^2$$

Where l_{nrf} is the length of the nanorods used in the nanoflower arrays.

The ratio of available surface areas where fluorophores can attach is now given by:

$$\frac{S''_{NF}}{S_{np}} = 5.77$$

Scattering properties of aligned nanorods and nanoflowers

The scattering properties of aligned nanorods and nanoflowers were investigated by measuring the total and diffuse reflectance in a Cary 5000 UV-VIS-NIR spectraphotometer. The results are shown in Figure 3. Absorbance of light was observed for all spectra at about 370nm- the band-gap energy of bulk ZnO (3.37eV). Comparing the data at 420nm, total reflectance and diffuse reflectance of nano-flower is 1.37 and 5.70 times as high as those of aligned nano-rods. Diffuse reflection is the predominant reflection for nanoflowers, the ratios of diffuse to total reflectance are 23.4% and 97.6% for aligned nano-rods and nano-flowers respectively. The capability for nanoflowers to scatter the light rather is verified and indicates a strong degree of randomness in the fabricated array.

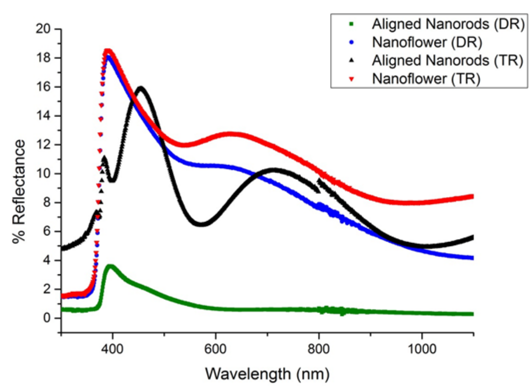

Figure 3. Total reflectance (TR) and diffuse reflectance (DR) of glass, aligned nanorods and nanoflower.