Supporting Information

UV Protection and Antioxidant Activity of Nanodiamonds and Fullerenes for Sunscreen Formulations

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Figure S1. Degradation of commercial sunscreens after being exposed to irradiation under solar simulator for 3 hours; transmittance graphs are seen to shift upwards over time. SPF of the sunscreens are reduced after irradiation with and without water bath temperature control. Temperature of water bath is kept at 20°C to prevent excessive heating of the samples. Degradation of the sunscreens is reduced by using this temperature control. A) Nivea SPF30 sunscreen showed a 62.5% reduction in SPF from SPF=31 at 0h to SPF=11.6 at 3h without water bath temperature control. B) Nivea SPF30 sunscreen showed a 11.4% reduction in SPF from SPF=28.9 at 0h to SPF=25.6 at 3h with water bath

temperature control. C) Nivea SPF50 sunscreen showed a 34.4% reduction in SPF from SPF=45.1 at 0h to SPF=29.6 at 3h without water bath temperature control. D) Nivea SPF50 sunscreen showed a 12.8% reduction in SPF from SPF=53.8 at 0h to SPF=46.9 at 3h with water bath temperature control.



Figure S2. TGA of salt-milled fullerene powder. Mass reduction at 400°C is attributed to the decomposition of fullerene. Fullerene accounts for 47.2% of powder mass while NaCl accounts for the remaining 52.8%.



Figure S3. Irradiation stabilization of C_{60} solution. A) Transmittance of C_{60} suspension at 25ug/ml (3ml in quartz cuvette) in the ultraviolet range over 7 hours of irradiation under the solar simulator with chilled water bath. Transmittance spectrum shifts upwards for the first 3 hours with decreasing magnitude of change and finally achieved stabilization from the 4th hour onwards without further upward shifts in the transmittance spectrum. SPF at 0H is 11.6 but is reduced to 6.4 at 7H. B) Photo showing the colour difference of C_{60} suspensions both at 25ug/ml with (right) and without (left) irradiation stabilization (7 hours of irradiation) which suggests a change in particle size. C) Graph showing the change in C_{60} particle size distribution between freshly diluted C_{60} suspension, diluted C_{60} suspension that is kept in the dark for 7 hours, and C_{60} suspensions have a final concentration of 25ug/ml. Refractive index of fullerene is 2.2 and absorption is 0.205. The C_{60} suspension freshly diluted from stock solution of 2mg/ml has a Z-average diameter of 127nm, particle size slightly increased to 137nm when the diluted sample is kept for 7 hours in the dark, and the C_{60} particles further aggregated after irradiation stabilization to a Z-average size of 230nm. The irradiation stabilized C_{60} appears to be bimodal in size distribution with the first peak at around 119nm and a second at 577nm.



Figure S4: Graph showing the change in size (vol%) of ND in serum over time. ND stock solution of 10mg/ml is probe sonicated and incorporated into serum made in-house in a 1:1 volume ratio to produce a formulation with 0.5wt% ND in serum. 20µl aliquots of each serum is aspirated at the stated time points and diluted in 500µl of deionized water immediately before size measurement. The initial probe sonication of ND stock solution prior to serum incorporation generates fine particles around 50nm but these particles appear to have aggregated into larger clusters by 4hrs. The larger clusters appear to be relatively stable and did not undergo significant aggregation within 72hrs. ND in serum has a bimodal distribution initially. The values above each column reflect the volume percentage of ND in each mode. *p<0.05, **p<0.01



Figure S5. Graph showing the change in size (vol%) of C_{60} nanoparticles in serum over time. C_{60} stock solution of 2mg/ml is probe sonicated and incorporated into serum made in-house in a 1:1 volume ratio to produce a formulation with 0.1wt% C_{60} in serum. 20µl aliquots of each serum is aspirated at the stated time points and diluted in 500µl of deionized water immediately before size measurement. The initial probe sonication of C_{60} stock solution prior to serum incorporation generated fine particles around 50nm. In contrast to ND (Figure S4), the C_{60} nanoparticles are more stable and did not aggregate. Thus, a bimodal distribution in serum is maintained with no significant aggregation within 72h.



Figure S6: Graph showing the distribution of TiO_2 nanoparticles by volume after the cream is stored untouched for 6 months. 20μ l aliquot is aspirated and diluted in 500μ l deionized water immediately before measurement.