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Effect of dispersing media on nanoparticles reactivity

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Introduction: Biological effect of nanoparticles (NP) appear to be related not only to surface or size but also to their ability to generate free radicals or oxidants, either through cell activation or intrinsically. The acellular in vitro dithiothreitol (DTT) assay allows such a measurement. Moreover, carbon based NP which were shown to be highly reactive toward DTT activate heme oxygenase-1 and deplete glutathion in in vitro cellular tests. This test could be useful for screening the potential toxic effect of carbon based manufactured NP.

Objectives: (1) to evaluate the effect of different dispersing conditions toward NP redox activity on DTT (2) to assess the oxidative capacity of different types of NP with the DTT test, i.e three black carbon (FW2, Printex60, FS101 from Degussa), one diesel particulate (SRM 2975) and one amorphous fumed silica used in industrial processes (Carb-O-sil TS-610, Cabot).

Material and method: Four different suspension media (deionised bidistillated water, Tween80 with concentrations ranging from 0.6 to 5.9 mg/L) and different ultrasonication time (0 to 30 min using a 180 Watt water bath) were tested for suspending FW2 particulates (used as model). For each conditions, the redox activity was assessed with the DTT assay, slightly adapted from Cho et al., Environ.Research, 2005, 99:40-47.

Results: We observed an exponential decrease of the FW2 mediated DTT oxidation rate with increasing Tween80 concentration. The reactivity changed from 170±22 pmol DTT consumed.min^{-1}.µg^{-1} in water to 35±12 pmol DTT consumed.min^{-1}.µg^{-1} in Tween80 5.9 mg/L. In contrast, diesel exhaust particulate showed a constant reactivity of 63±22 pmol DTT consumed.min^{-1}.µg^{-1}. Increasing the ultrasonification time of the FW2 suspension lead to a two time increase of the DTT consumption rate, reaching a plateau after 15 minutes.

The DTT oxidative capacity (in pmol DTT consumed.min^{-1}.µg^{-1}) of the tested NP were the following: FW2(114±13)>SRM 2975(41±5)>Printex60(17±11)~FS101(not reactive)~Carb-O-sil TS-610(not reactive). When expressed in function of BET surface (nmol DTT consumed. min^{-1}.m^{-2}), the order is slightly different, with SRM 2975 (450±100)>FW2(280±70)>Printex6 0(150±90)>FS101(not reactive)~Carb-O-sil TS-610(not reactive)

Discussion and conclusions: The suspension media and surfactant concentration seem to be key parameters influencing the DTT reactivity of NP. The decrease of reactivity for FW2 in function of increasing Tween80 concentrations could be due to surfactant adsorbing on the particulate surface, thereby reducing the available reactive sites. As diesel particulate is already coated with an organic layer, adsoption of the surfactant is not possible and thus has no effect on it reactivity. The decreased reactive surface of FW2 may explain the order inversion observed when reactivity is expressed as BET surface.

The use of such a simple test indicates that FW2 and SRM 2975 have a strong intrinsic potential to oxidize sulfur containing molecules.