Supporting information for: Uptake dynamics of graphene quantum dots into primary human blood cells following in vitro exposure

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Abstract

The supporting information provides further data regarding the characterization of the graphene quantum dots and the fluorescence measurements used to quantify the uptake of the quantum dots by the cells.

Keywords

Graphene Quantum Dots, Leukocytes, Nanoparticles, Fluorescence spectroscopy, Toxicity

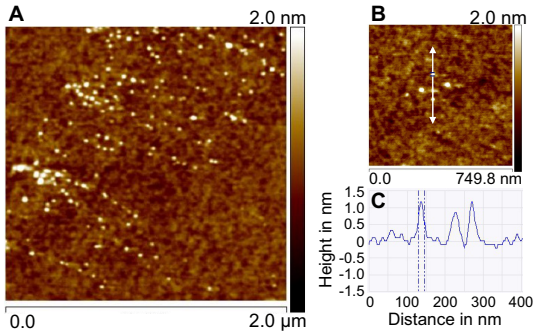

Figure S 1: The GQDs deposited on SiO_2 as seen by an atomic force microscope. Their apparent width is $\approx 20\,\mathrm{nm}$, which is much larger than their true width, in accordance with earlier works. The height of less than 1 nm indicates single-layer graphene.

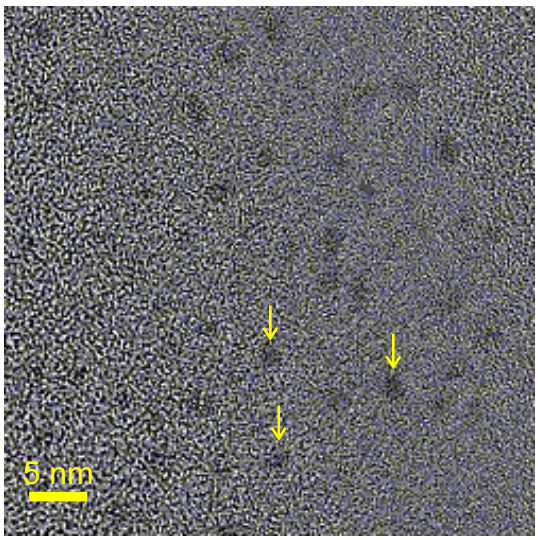

Figure S 2: Transmission electron microscope picture of the graphene quantum dots used in the experiment. The quantum dots appear as full, dark circles on top of the substrate, an amorphous carbon grid of 5 nm thickness. Some of the dots are marked by an arrow.

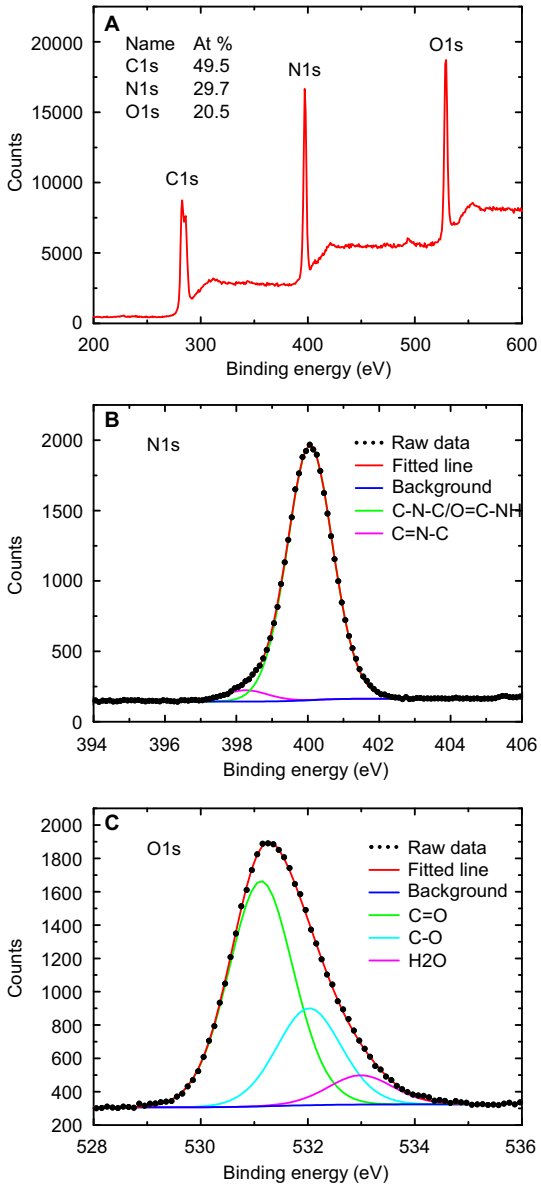

Figure S 3: (A) Overview of the XPS spectrum of the GQDs. the three dominant peaks are due to the electrons excited form the 1s staes of the carbon, nitrogen and oxygen atoms, respectively. The fine structures of the N1s- and O1s- resonances are shown in (B) and (C), respectively. Their best fit analysis is in qualitative agreement with that one of the C1s - peak discussed in the main text. In particular, the absence of nitrogen-oxygen bonds is remarkable.

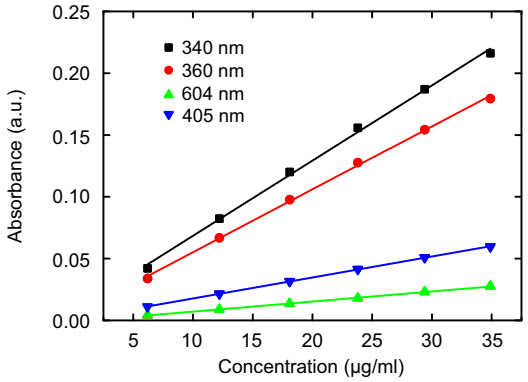

Figure S 4: The dependence of the absorbance of the GQD solutions depends linearly on the GQD concentration and implies that the absorbance of the solvent is negligible.

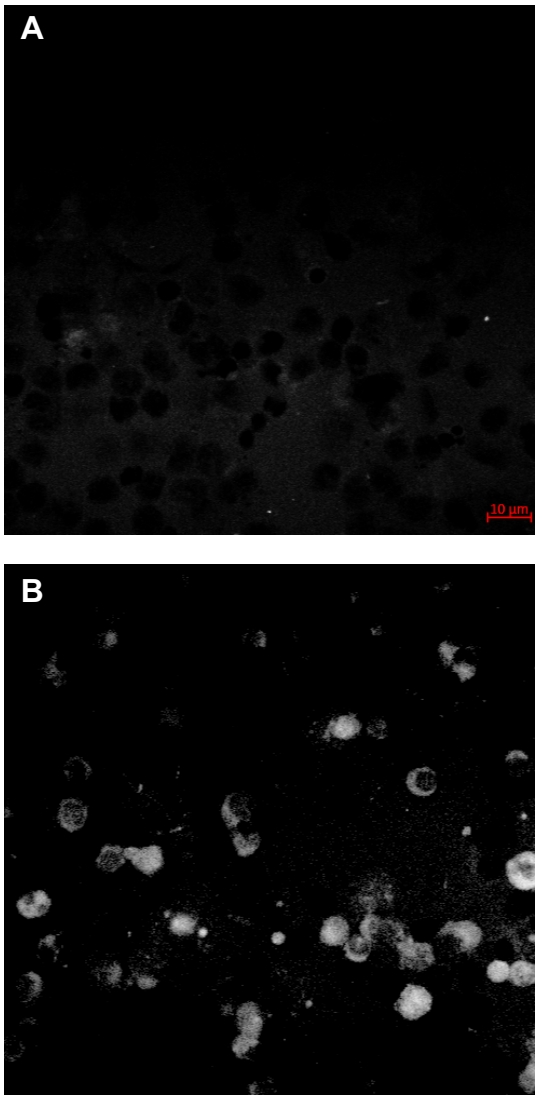

Figure S 5: Fluorescence intensity of the cells prior to (upper part) and after exposure to GQDs for 36 hours (lower part), as observed in a confocal optical microscope. Before the exposure to GQDs, the cells appear as dark with respect to a slightly fluorescent environment. After the exposure, the GQD - induced fluorescence inside the cells dominates the picture. All microscope parameters are identical, such that the comparison of the intensities by eye can be taken as a qualitative measure of the uptake.

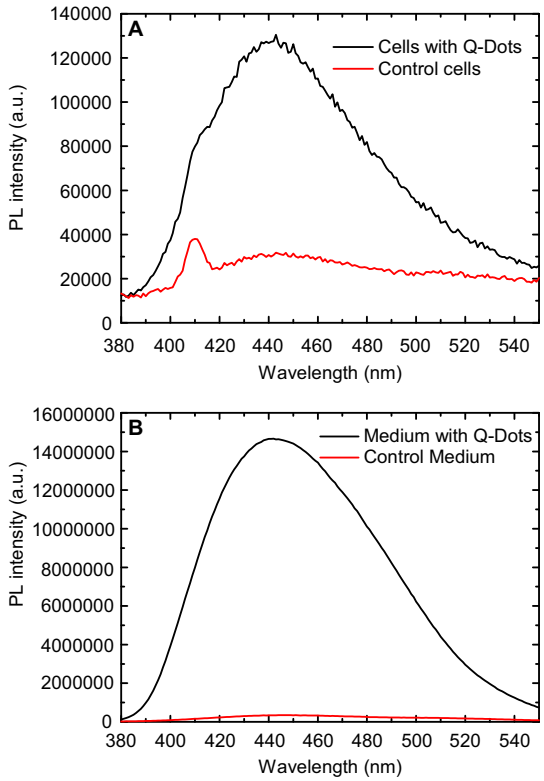

Figure S 6: Fluorescence spectrum of the GQDs in the cells (A) in comparison to that one obtained for the solution prior to the addition of the cells (B). After the Raman peak at a wavelength of 410 nm has been removed, the ratio of the integrated intensities, corrected by the intensity of the control, corresponds to the fraction of the absorbed GQDs.

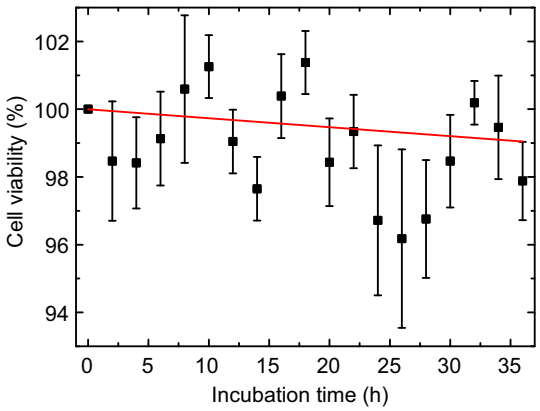

Figure S 7: Control experiment of the cell viability in the culture medium, as specified in the experimental Section (paragraph on cell preparation), in the absence of GQDs.