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Graphene Quantum Dots: Physico-Chemical Characterization and In Vitro Biological Effects †

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Abstract: Graphene quantum dots (GQDs) represent nanoscale structures with strong quantum and exceptional photoluminescence properties. These particles have promising applications in nanomedicine, specifically for diagnostics, cargo delivery, photothermal therapy and bioimaging. In this context, we aimed to characterize GQDs available on the market for further utilization for in vivo purposes. Transmission and scanning electron microscopy (TEM and SEM), and energy dispersive X-ray spectroscopy (EDX), were used to characterize the morphology and elemental composition of GQDs. In addition, the hydrodynamic size and the zeta potential were measured for these nanoparticles. Their biocompatibility was investigated on human fibroblast lung cells (MRC-5 cell line) after 24 and 72 h of incubation with concentrations up to 200 μg/mL of GQDs. TEM images showed graphene sheets with few wrinkle structures, the dots having uniform diameters in the range between 1.0 and 5.0 nm. SEM examination revealed the three-dimensional structure with a sponge-like aspect and pores of various sizes. Their tendency to aggregate provided the formation of aggregates with sizes of hundreds of nanometers, as revealed by the hydrodynamic diameter of about 270 nm. A negative zeta potential of −16 mV confirmed the anionic character of GQDs. Concentrations up to 50 μg/mL exhibited a low toxicity in lung cells, as revealed by MTT assay and fluorescent microscopy of actin cytoskeleton after both time intervals, confirming potential further testing on animals for clinical purposes. However, the high doses of GQDs induced cell death and must be avoided in future. Given the new experimental evidence obtained on GQDs, more knowledge has been achieved, which is very useful for prospective research to revolutionize the future of nanomedicine and biotechnology.

Keywords: graphene; quantum dots; biocompatibility

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1. Introduction

Graphene quantum dots (GQDs) represent nanoscale structures with strong quantum and exceptional photoluminescence properties. These particles have promising applications in nanomedicine, specifically, for diagnostics, cargo delivery, photothermal therapy and bioimaging [1,2]. In this context, we aimed to characterize GQDs available on the market for further utilization for in vivo purposes.

2. Materials and Methods

Transmission and scanning electron microscopy (TEM and SEM), and energy dispersive X-ray spectroscopy (EDX), were used to characterize the morphology and elemental composition of GQDs. In addition, the hydrodynamic size and the zeta potential were measured for these nanoparticles. Their biocompatibility was investigated on human fibroblast lung cells (MRC-5 cell line) after 24 and 72 h of incubation with concentrations of up to 200 μg/mL of GQDs.

3. Results

TEM images showed graphene sheets with few wrinkle structures, the dots having uniform diameters in the range between 1.0 and 5.0 nm. SEM examination revealed the three-dimensional structure with a sponge-like aspect and pores of various sizes. Their tendency to aggregate provided the formation of aggregates with sizes of hundreds of nanometers, as revealed by the hydrodynamic diameter of about 270 nm. A negative zeta potential of −16 mV confirmed the anionic character of GQDs.

Concentrations up to 50 μg/mL exhibited a low toxicity in lung cells, as revealed by the MTT assay, phase contrast images (Figure 1) and fluorescent microscopy of actin cytoskeleton (Figure 2) after both time intervals, confirming potential further testing on animals for clinical purposes. However, the high doses of GQDs induced cell death and must be avoided in future.

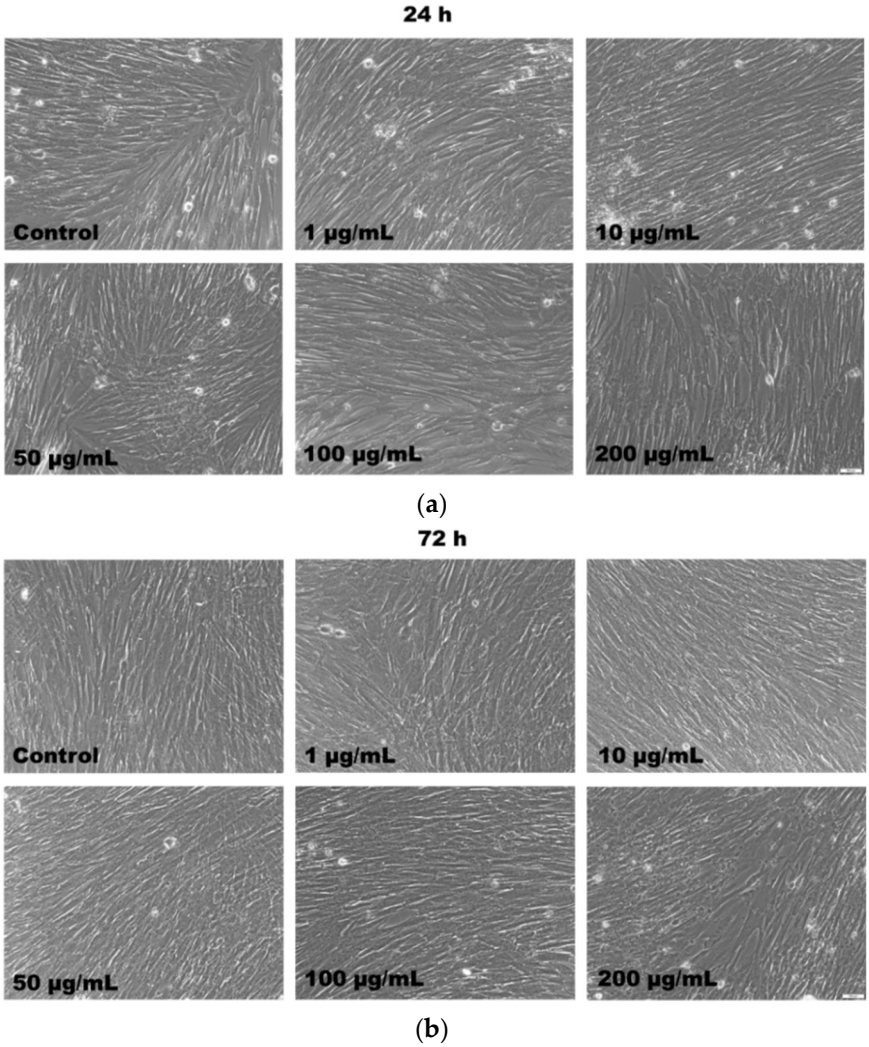

Figure 1. Phase contrast images of MRC-5 cells incubated with graphene quantum dots (GQDs) for 24 (**a**) and 72 h (**b**).

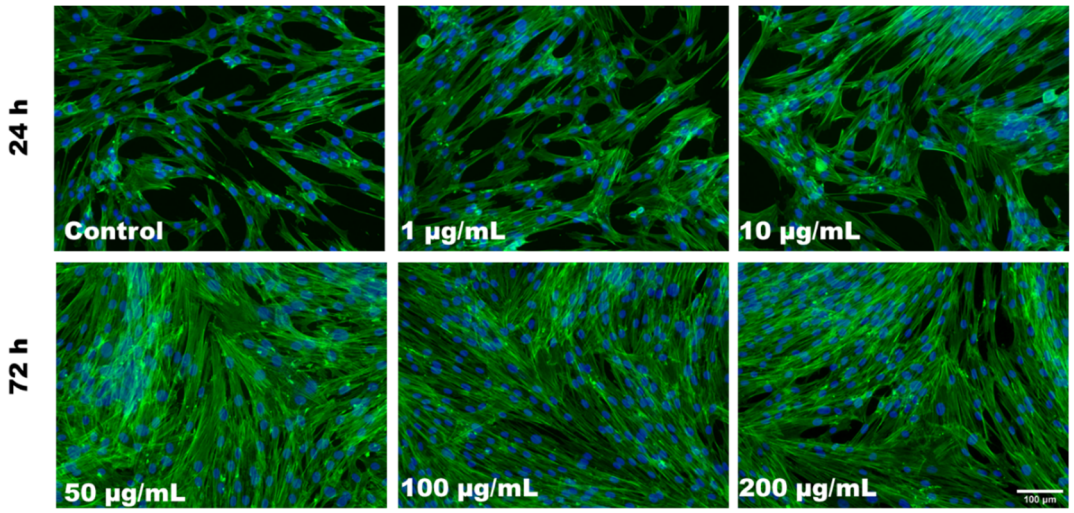

Figure 2. Fluorescence images of F-actin in MRC-5 cells incubated with GQDs for 24 and 72 h.

4. Conclusions

Given the new experimental evidence obtained on GQDs, more knowledge has been achieved, which is very useful for prospective research to revolutionize the future of nanomedicine and biotechnology.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/IOCN2020-07911/s1.

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