Size dependence effects of Aluminium oxide nanoparticles on red blood cells

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Abstract

The interaction of nanomaterials (NMs) with cell membranes is an important research area because it is critical in many applications [1] and the effects of NMs on cell membranes are worth attention for both their applications and safety assessments. Aluminium oxide NMs are the most abundantly produced and used in diverse fields such as medical, military and industrial purposes [2]. Examining the influence of shape and size of NMs on cell interactions is crucial as these can have implications in toxicity [3]. The haemolysis assay is recommended as a reliable test for material biocompatibility [4]. Particle size and surface are key factors that affect haemolysis. In the case of silver nanoparticles, it was observed that a distinct increase in the haemolytic properties of nano-sized particles compared to the micron-sized particles at equivalent mass concentration [5]. In this work we have studied the effect of three different commercial nano-sized aluminium oxides on red blood cells, compared to the micro-sized aluminium oxide. The method used was the haemolysis assay as described in previous papers [6] and adapted to the study of NMs. Briefly, red blood cells obtained by centrifugation from fresh blood were incubated at 37ºC and at room temperature for 24 hours with different concentrations of the different types of aluminium oxide. At the end of the incubation period, tubes were centrifuged and the amount of haemoglobin on the supernatant has been determined by spectroscopy at 540 nm to determine the percentage of haemolysis induced by the chemicals, compared to blood totally haemolysed.
We have used red blood cells from human, rat and rabbit, showing a different behaviour. Red blood cells from rabbits were more affected by the nano-sized aluminium oxide than human or rat red blood cells. By contracts, similar results were observed for micro-sized aluminium oxide in the three species (Figure 1)
The addition of albumin induced a significant reduction on the haemolytic effect of the nano-sized aluminium oxide expressed by an increase in the HC_{50} (concentration that induces 50% of haemolysis), compared to the micro-sized one which presents no effect (Figure 2). Another factor to be into account when comparing studies of haemolysis is the temperature of incubation. The hemolytic activity of the nanoparticles increased with temperature in line with other studies performed with silica particles [7]. Interestingly, the temperature dependence of hemolysis varied among the aluminum oxide nanoparticles.
In conclusion, size and shape of aluminium oxide nanoparticles influence the interaction with cell membrane. These results should be taken into account when synthesizing new nanomaterials more safe with less effect on health.

References

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Figures

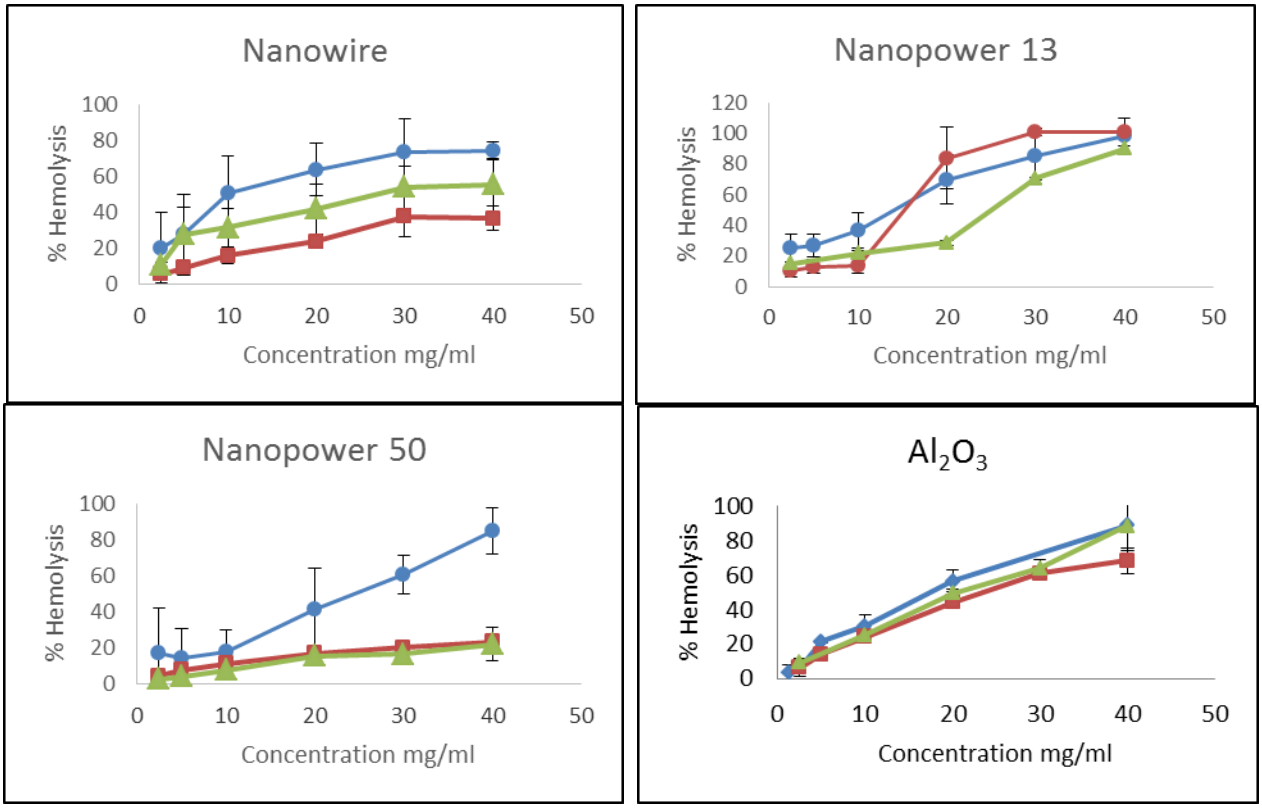

Figure 1. Behaviour of human, rabbit and rat erythrocytes in front of different aluminium oxide nanoparticles and macroscopic aluminium oxide (▲human, ● rabbit, ■ rat)

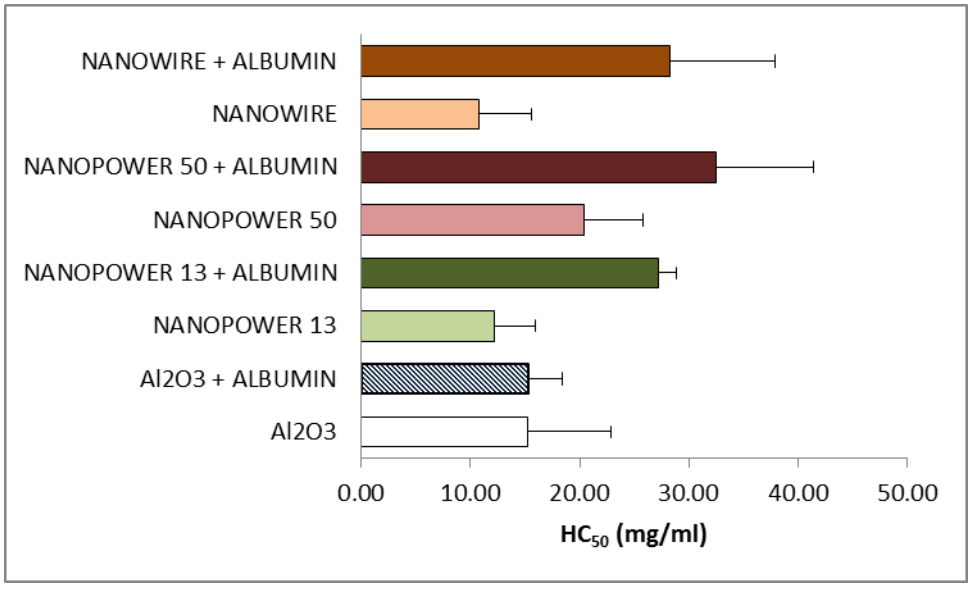

Figure 2. Effect of albumin addition on the haemolysis induced by different Al_2O_3 nano forms and micro-sized Al_2O_3 on rabbit red blood cells.