Development of Antifouling Polymer-Coated Nanodiamonds for Biological Applications

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Abstract

Due to their tunable surface structures and biocompatibility, nanodiamonds (NDs) are promising candidates in a broad range of biomedical applications, including drug delivery and bioimaging [1]. However, NDs produced by detonation have a notable tendency to form tight aggregates in biological media.

In this regard, controlling protein adsorption on NDs *via* the engineering of adequate antifouling coatings is critical for the design of biologically relevant NDs. We selected click chemistry for the covalent attachment of antifouling polymers on the surface of NDs. The selective cycloaddition of azides to alkynes is highly efficient and can be carried out under aqueous conditions. We investigated in 2011 the antifouling properties of a fluorosurfactant known as Zonyl (M_w 725) having a first block based on a perfluoroalkyl chain followed by a poly(ethylene glycol) block [2]. NDs were functionalized with azide groups using 4-azidobenzoic acid and subsequently coupled with the alkynyl-terminated Zonyl. The adsorption of bovine serum albumin (BSA), which is the most abundant protein in plasma and serum, on NDs was quantified and was found to be reduced by 30% in the presence of the Zonyl layer.

Following this promising result, we conducted further experiments to gain insight about the associated mechanisms of adsorption using standard cell culture medium supplemented with fetal bovine serum as a complex biological fluid [3]. Zonyl and two other polymers, namely a low molecular weight poly(ethylene glycol) (PEG) and a zwitterionic (zwit) sulfobetaine, were attached on NDs. Protein fouling was found to be two-fold lower with Zonyl and zwit coatings, and six-fold lower with PEG coating in comparison with the unmodified particles. These results, along with a modelization of the particle-protein interface, suggest that NDs are covered first by a stabilizing monolayer of high affinity serum proteins, this monolayer being then substituted by proteins of lower affinity.

Future studies will be required to map the dynamic protein bio-corona formed around the NDs since it is known to dictate the overall particle behavior in biological environments.

References

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